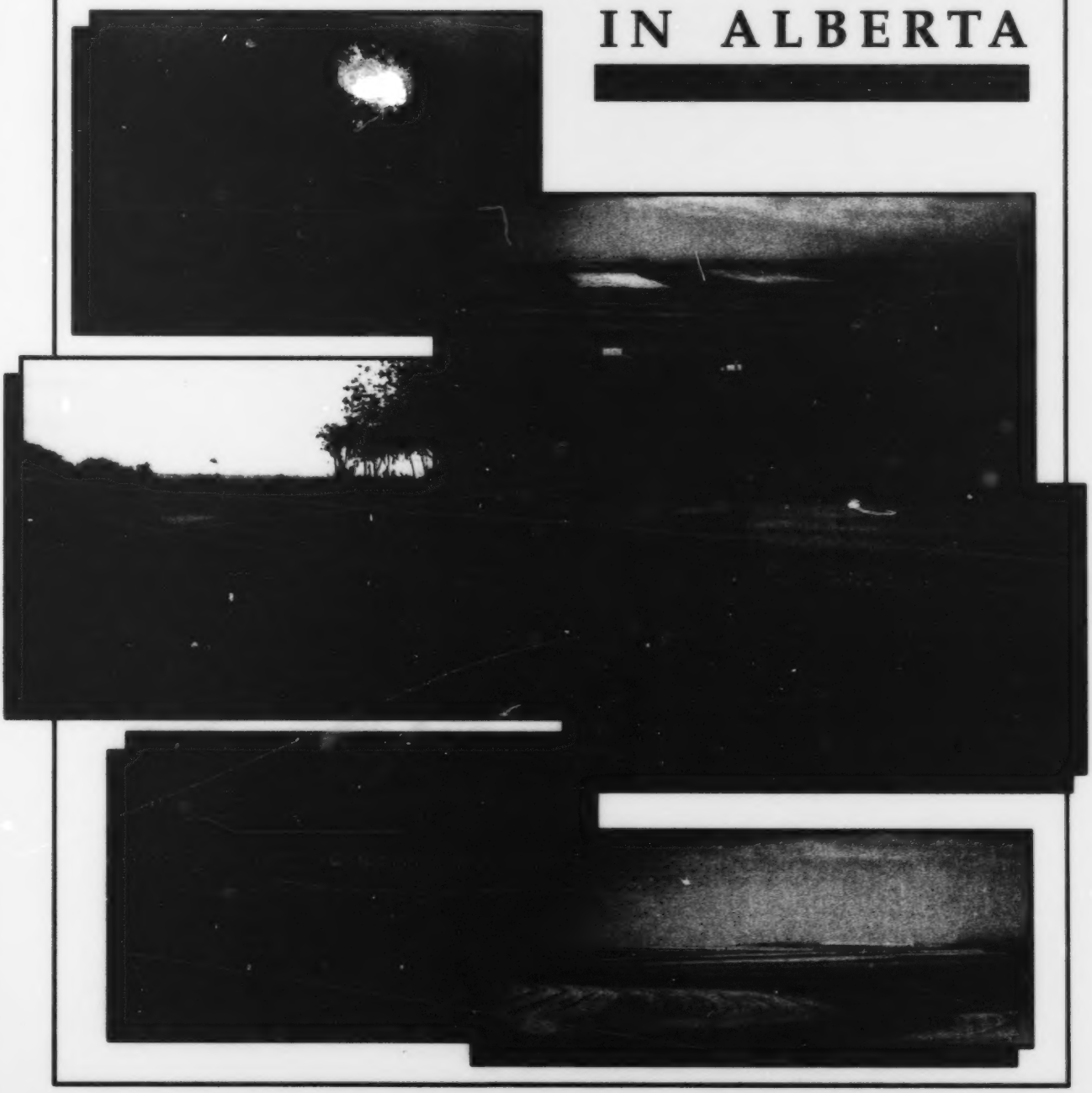
THE STORY OF
Soil and Water Conservation
IN ALBERTA



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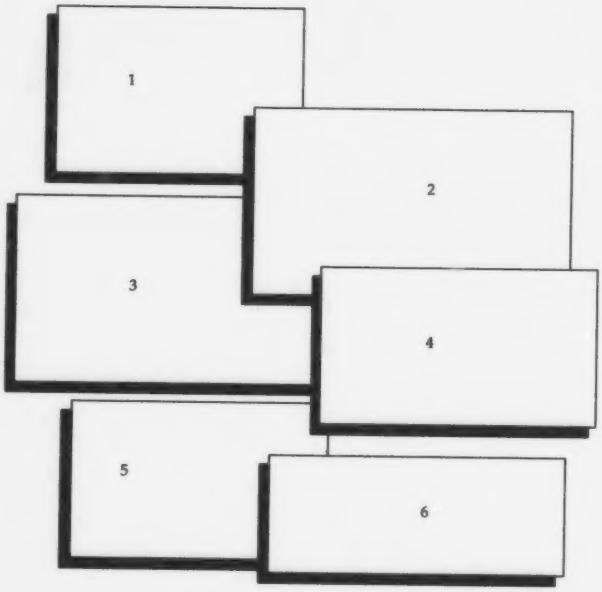

Cover Photographs

1. A "black blizzard" in 1988, a few miles east of Edmonton.

2. Where strip cropping began in Alberta about 1918, just west of Monarch, near the Oldman River.

3. Drift soil in a fence row northeast of Edmonton.

4. A blade weeder in operation leaving plenty of plant residue on the soil surface.

5. A gully cutting a field in two. Note absence of plant residue on the fallowed field.

6. Strip cropping on the contour and a grassed-in watercourse near Nobleford.

THE STORY OF
Soil and Water Conservation
IN ALBERTA

by Dr. J. A. Toogood
Professor Emeritus,
Department of Soil Science,
University of Alberta

Foreword

The Province of Alberta has been blessed with productive soils and plentiful water resources. Although many of our lands have been farmed for less than a century, we have witnessed the threat of severe wind and water erosion and other forms of soil degradation. The people of Alberta have responded to these challenges and are implementing management practices that will preserve our soil and water resources for future generations.

The Alberta Chapter of the Soil and Water Conservation Society welcomes this effort to document the story of soil and water conservation in Alberta. This booklet in no way attempts to tell the entire story of conservation in Alberta but instead presents an overview of the type of challenges we face and some of the ways used in tackling them. We are particularly pleased that Dr. John A. Toogood, who taught soil conservation to hundreds of under-graduate students at the University of Alberta, was willing to undertake the important task of writing this story.

We would like to recognize both Agriculture Canada and Alberta Agriculture, through the Canada/Alberta Agreement on Soil, Water and Cropping Research and Technology Transfer (CARTT), for covering all of the development and printing costs.

John C. Hermans
President, Alberta Chapter
Soil and Water Conservation Society
January, 1989

SOIL WATER CROPPING
CARTT Canada/Alberta Research and Technology Transfer

Agriculture Canada

Alberta AGRICULTURE

SWCS ALBERTA

Our Soil and Water

This soil of ours, this precious heritage, what an unobtrusive existence it leads! While the carpet of grass or crops conceal it, the beauty and splendor of flowers and trees distract our attention from it. To the rich soil let us give the credit due. The soil is the reservoir of life. Here the smallest seeds find shelter and the urge for germination and growth; here live, in countless varieties, myriads of micro-organisms, busy with their alchemies of life; here are the minerals calcium, phosphorus, nitrogen - a list of fifteen or more - which plants, and animals, and man in turn, must have for their well-being. And like any other reservoir this one too can be drained and left empty and useless; let but the winds and the rains strike at the fallowed fields; let but the naked soil be exposed to the elements - how soon and how tragic the loss. The fruits of countless ages vanish; impoverished crops, livestock, and people take their place. How selfish the man, how short-sighted his view, who does not cherish and protect this heritage in his care !

And our water, the universal solvent, present in the air, in the soil, in plants, animals and man. Without it life could not endure. From the atmosphere it falls as rain or snow; in the soil, with its dissolved plant nutrients, water is taken in by the roots of crops; in their leaves it becomes a raw material in the photosynthetic processes, which produce a complex variety of compounds. More water then acts as a carrier, transporting the products to the storage areas in the plant, seeds, stems, and roots. Thus water is a key to life on earth because these stored products then provide food for animals and man. Good water supplies are therefore a vital resource which man neglects at his own peril. The conservation of this resource in a land where the rains are not always timely, and where water supplies are limited or not readily available, is as necessary as the conservation of its soil.

J.A.Toogood
NW27-24-21-W4

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Acknowledgements

The Alberta Chapter of the Soil and Water Conservation Society is grateful to the federal and provincial governments, through the Canada/Alberta Agreement on Soil, Water and Cropping Research and Technology Transfer (CARTT), for the financial support which has made this publication possible.

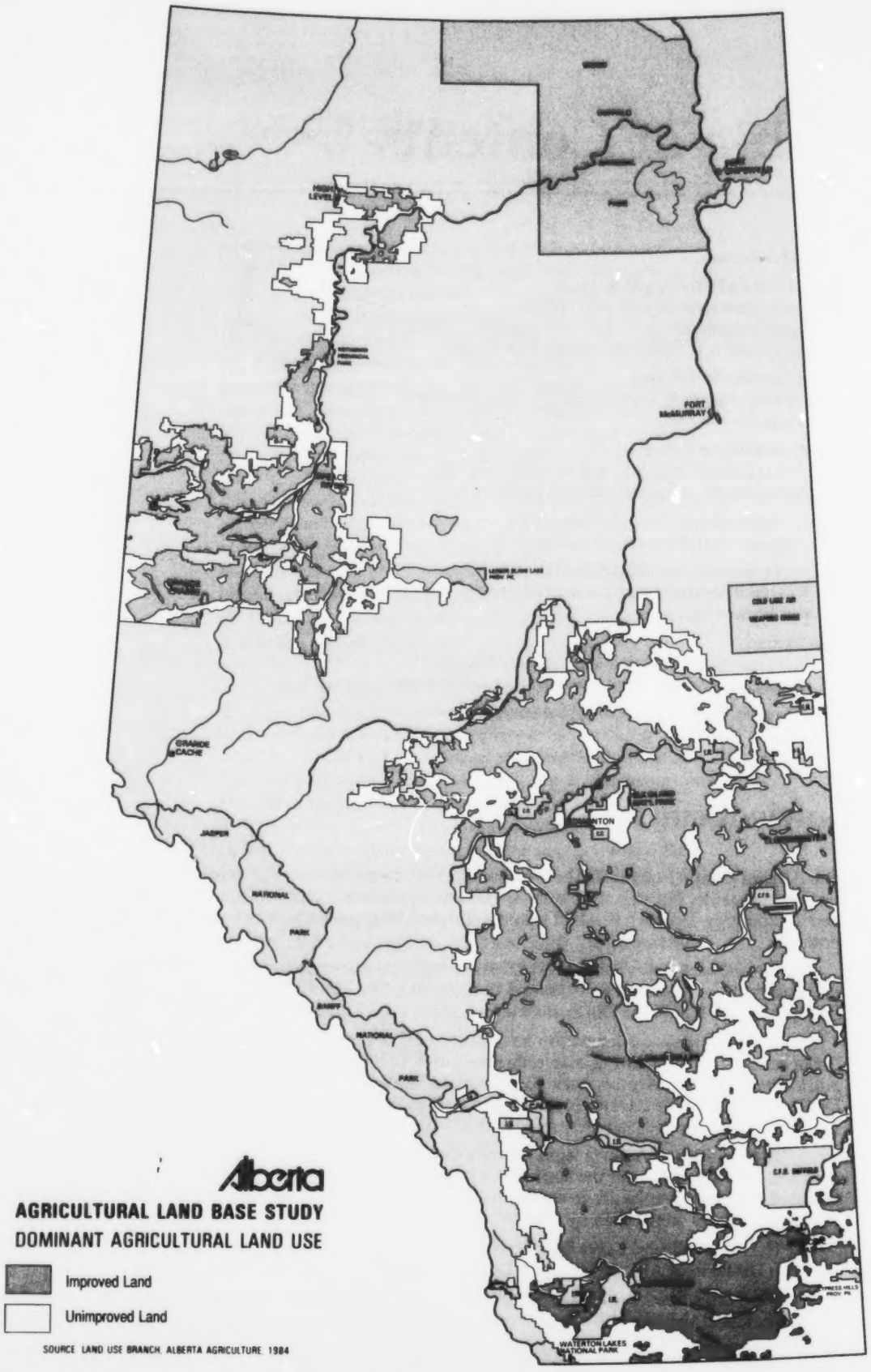
The author acknowledges the valuable suggestions made by his Advisory Committee, namely: R.T. Adam, J.G. Calpas, A.W. Goettel, J.C. Hermans, Dr.C. W.Lindwall, P.G. Melnychuk, Dr.W.W. Pettapiece, and R.S. Reid. The author is grateful to Don Myhre for artwork and design.

Many sources of information have been used in preparing this story and they are among the list of references and reading materials presented. Publications of the Lethbridge Research Station, Agriculture Canada, Atmospheric Environment Service, Alberta Agriculture and the Soil Science Department of the University of Alberta as well as those of non-governmental organizations and of individuals, have provided facts and figures.

The facilities of Alberta Agriculture's Conservation and Development Branch were made available to the author and the staff of the Branch were a great help in the preparation of this story. Some of the photographs are from the Branch's slide collection, several having been taken by J.C. Hermans. Others were taken by Dr. C.F. Bentley and by the author.

The "Agricultural Land Base Study" map is from a report prepared for The Land Information Services Division of Alberta Forestry, Lands and Wildlife.

The Water Resources Management Services of Alberta Environment supplied the map of River Discharges, and the Irrigation Resource Management Division supplied the map of the Irrigation Districts.



Alberta

AGRICULTURAL LAND BASE STUDY

DOMINANT AGRICULTURAL LAND USE

Improved Land

Unimproved Land

SOURCE: LAND USE BRANCH, ALBERTA AGRICULTURE, 1984

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA ENERGY AND NATURAL RESOURCES, 1985.

Time Line and Historical Review

10000 BP

Nomadic Indian tribes roamed what is now Alberta from the time the Pleistocene ice sheets retreated until the first European explorers and fur traders arrived. Henry Kelsey, sent by the Hudson's Bay Co.in

1684 AD

1684, was probably the first European explorer.

Wild game, especially bison, were

1730

here in abundance. In the 1730s horses, together with traders and guns made their appearance. It is estimated that the "Plains Indians" numbered about 30,000 at that time.

1754

In 1754 Anthony Henday explored along the Battle and North Saskatchewan Rivers. He was followed by David Thompson, Peter Fiddler, and Alexander Mackenzie, all of whom worked for the great fur trading companies, the Hudson's Bay Co. and the North West Co. The first

1778

recorded white development was Peter Pond's Fort on Lake Athabasca in 1778. In 1784 the map of the prairies from Lake Winnipeg to the Pacific was a blank but by 1814 Thompson's explorations and mapping had filled the void, and Mackenzie had explored northward to the Arctic and westward to the Pacific.

1795

Ft. Edmonton was established as a fur trading post in 1795, and at that time there were many other posts along the Saskatchewan, Athabasca and Peace Rivers, since transport of goods and furs was mainly by water.

1857

From 1857 to 1860 Captain John Palliser led an expedition across the southern prairies to assess their value as land for colonization. His conclusion was that the short-grass plains were semi-arid and unsuitable. In the 1870s John Macoun led a government survey of the prairies. Unlike Palliser, he concluded they were ideally suited for agriculture. This was one of the reasons the southerly route for the trans-Canada railway was selected over the more northerly one that was being considered.

1874

The Royal Canadian Mounted Police established Ft. Macleod in 1874 to halt the whiskey trade and maintain peace in the area. A fort at Calgary was established the next year. Meanwhile the native tribes were in trouble: the bison were being hunted to extinction, there was friction with traders, smallpox and starvation were taking a toll, all were leading to a rapid decline in the native population, a decline that continued until 1920.

During the 1870s, while bison were vanishing from the plains, range cattle began to make their appearance, and for several decades ranchers became common in southern Alberta.

1881

In the year 1881 it is estimated that there were only about 1000 non-native settlers in what is now Alberta. One of these started the first irrigation project, just south of Calgary, in 1879. With the arrival of the Canadian Pacific Railway in Calgary in 1883 and its completion across the mountains to

1885

Vancouver in 1885, and a branch line to Lethbridge that same year, settlers began to arrive in ever-increasing numbers. In 1891 a rail line to Edmonton was completed. The number of settlers in that year was estimated at 17,500. In that year too the first township was mapped in Alberta under the Western Canada Land Survey program.

1891

By 1891 there were several private irrigation schemes in operation in southern Alberta. In the next twenty years several irrigation companies were organized, to be replaced later by government organized and government supported Irrigation Districts.

1905

The province of Alberta was established with Edmonton as capital city in 1905, the same year that what is now the

Canadian National Railway reached the city on its way via the Yellowhead route to the Pacific. More settlers streamed in and by 1911 Alberta's population was up to 374,000. By 1921 the figure was 584,000 and by 1961 1,332,000.

The fur traders and explorers had observed the tar sands along the Athabasca
1912 River and natural gas wells were developed in southeast Alberta in 1912. A pipeline to Calgary was built that year. Two years later the Turner Valley oil field was discovered. It was in 1947, however, with the discovery of
1947 oil in the rich Leduc oilfield southwest of Edmonton that the oil and gas industry in Alberta suddenly began a rapid growth. With this expansion came the growth of many small industries.

So the focus of trade and industry in what is now Alberta shifted from beaver and bison in the early days, to agriculture starting in the 1870s, and since 1947 to the oil and gas industry. The gross domestic
1985 products at factor cost in 1985, according to the Bureau of Statistics ranked as follows:

Mining (Oil,gas & coal)	27.0 %
Services	13.0
Finance	13.0
Trade	8.0
Nat. Resource Royalties	8.0
Transportation	6.0
Manufacturing	6.0
Public Administration	5.0
Construction	5.0
Utilities	3.0
Agriculture	3.0
Forestry	0.1

1987 The 1987 population was 2.4 millions, with a native population of 2.7 per cent. The major ethnic origins of the population were: British - 43 per cent, German - 10 per cent, Ukranian - 6 per cent, and French - 5 per cent. Many of the early settlers were immigrants from the United States. The cities of Calgary and Edmonton now contain roughly half the people in the province.

By 1987 over 10 million hectares of land were being used for crop production and as much again for natural pasture and rangeland. (See map facing page 1.)

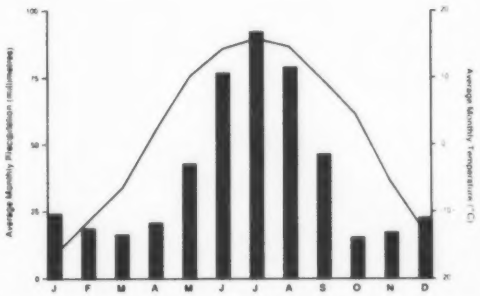
Alberta's Resources of Soil and Water

Agricultural Resources of Alberta

The province extends from 49 to 60 degrees North Latitude and from 110 to 120 degrees West Longitude, except for the southwestern corner where the boundary is the continental divide. The province thus extends 1220 km (762 mi) north to south and 654 km (409 mi)from west to east at its widest point. How big is this? Alberta's area is equal to that of California and Oregon combined, and just under the size of Texas. It is more than double the size of the United Kingdom.

Large areas of the northern half of the province are however very sparsely populated, only about one-third of the total area being used for arable agriculture and rangeland. The map facing page one shows the areas most densely settled, namely the Edmonton and Calgary areas in the southern half of the province and the Peace River area to the northwest.

Alberta is in the north temperate climatic zone. The graph of monthly precipitation and temperature for Edmonton's International Airport shows that winters are relatively dry and cold and summers moist and warm. While winter temperatures at Edmonton occasionally drop below -40 C, summer temperatures rarely reach 35 C.



Average monthly precipitation and temperature at Edmonton

Northern Alberta experiences colder winter temperatures and southeastern Alberta has hotter summer temperatures. Daily fluctuations in temperature tend to be large due to the absence of the moderating influence of oceans or large lakes.

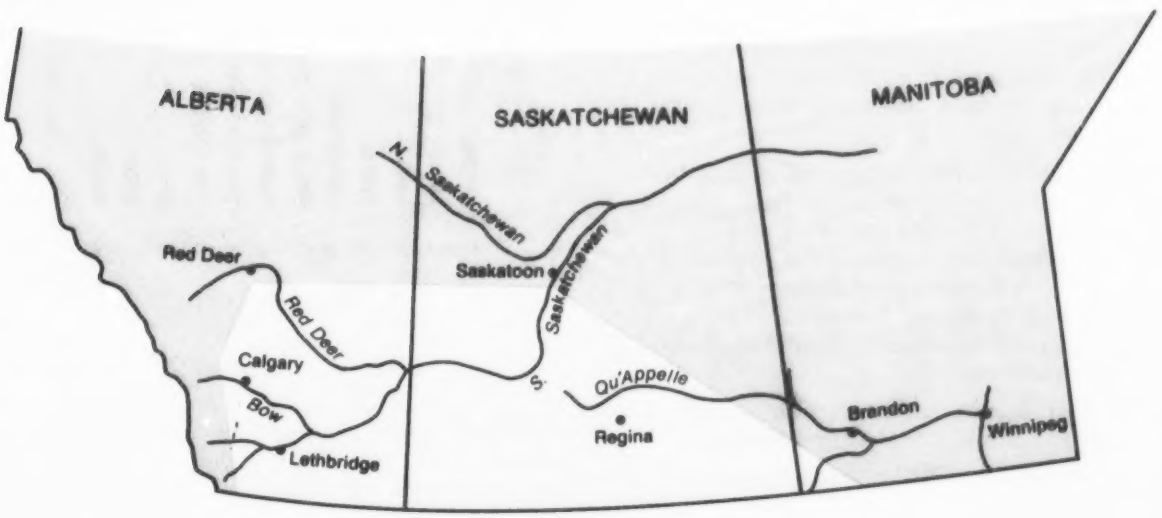
A special feature of Alberta's climate, and of major importance in soil and water conservation, is the chinook effect. These are warm dry winds

flowing eastward over the Rockies into south-western Alberta, particularly noticeable in the winter months. While a welcome relief from cold weather they can have detrimental effects on soil and may quickly melt snow cover and dry out the soil. Most of Alberta's Irrigation Districts are within the chinook belt.

Climatic conditions have resulted in a prairie region in the southeast portion of the province; north and west of this area the grasses grade into parkland, and finally forested and muskeg areas extending to the western and northern boundaries. The ecosystems recognized and their associated soils will be discussed later, and also more details about the climate.

Palliser (see historical review) referred to the short-grass area of the prairies as "a desert, forming a triangle having for its base the forty-ninth parallel from 100 to 114 degrees west longitude with its apex reaching to the fifty-second parallel of latitude". In a more detailed account of the boundary of this "triangle" he indicated a pentagon-shaped area illustrated in the accompanying map. This Palliser's triangle was to play an important role in the settlement of Alberta and in problems of soil erosion which developed. The treeless grasslands, later characterized as the Brown and Dark Brown soil zones, were an attraction for homesteaders, who flocked in, following completion of the transcontinental Canadian Pacific Railway, to take advantage of the cheap land offered for settlement. No land clearing was needed and large areas of fertile soil were soon plowed and planted. Sod shacks dotted the prairie landscape in the 1880s and 1890s since lumber was scarce and expensive.

By 1931 a network of railway lines extended across the prairie regions and few settlers were more than 10 miles from their nearest rail line. Settlement of the prairies was practically complete and new settlers were moving into forested areas of the province for their homestead sites. In fact by that time an exodus had already begun as settlers on the shortgrass plains were discovering that rainfall was inadequate for successful grain crop production. Dry years in 1921, 1922 and 1924 and the drought and depression years of the early 1930s hastened the exodus. Most of the settlers moved north and west to more humid parts of Alberta or settled in the new Irrigation Districts set up in southern Alberta.

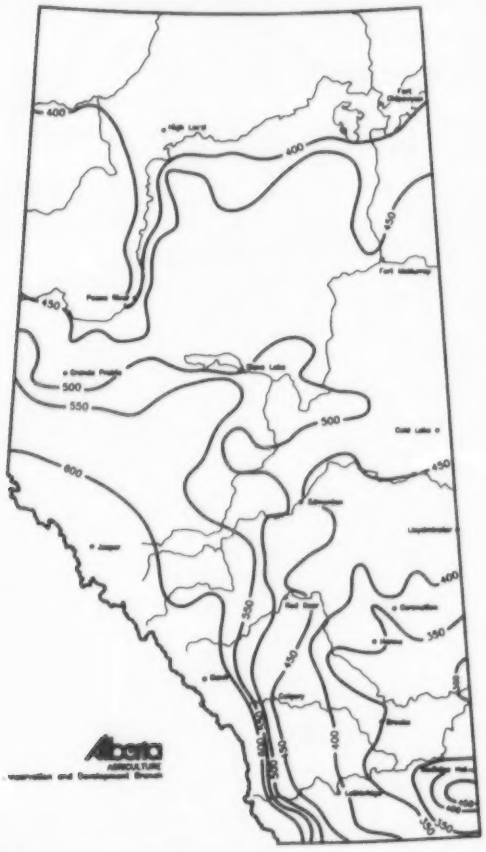


Sketch of the prairie region showing "Palliser's Triangle."

The Climate of Alberta

The annual precipitation in Alberta is shown on the accompanying map. Rainfall distribution is also shown on a graph for Grande Prairie, Edmonton, Calgary and Lethbridge.

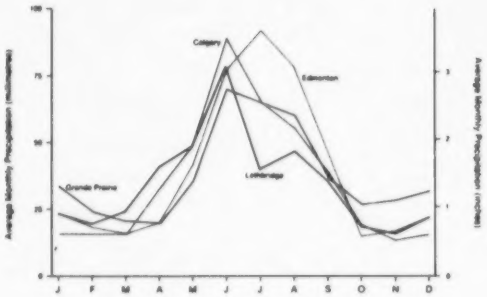
Annual Total Precipitation (mm) 1951-80



Alberta Agroclimatic Atlas, 1988
Map Analysis by Peter Dzikowski, P. Ag.
Based on Canadian Climate Normals, 1951 - 80
Atmospheric Environment Service, Environment Canada

Since the average dates for the last spring frost at the four locations are May 18, 25, 25 and 23 respectively, and for the first fall frost Sept.12, 8, 15 and 17, it is clear that about half of the rainfall comes in the frost-free growing season. The total rainfall received in the growing season is however

Seasonal Variation in precipitation at four major Alberta cities



quite variable, both as to total and as to when in the season it falls. At Lethbridge for example rainfall in the month of June has varied from 3.2 to 175 mm and at Edmonton from 11.4 to 190 mm. Much of Alberta's rainfall occurs in localized storms that cover only a narrow strip as they move across the countryside. Only rarely does rainfall cover large areas of the province uniformly on the same day.

Lack of sufficient rainfall is thus often a limiting factor in crop production, particularly in the southeastern part of Alberta, where total precipitation is generally less than 360 mm. In the Brown soil zone especially, where the figure is often less than 340 mm, irrigation is necessary for successful crop production. In the adjacent areas of the Dark Brown soil zone rainfall is not quite as critical a factor but crop yields frequently suffer from drought.

A rainfall feature of particular concern in water erosion is its intensity. How much falls in 10 minutes, in 30 minutes, in an hour, or in a day? To answer these questions recording rain gauges are necessary. Soil erosion studies use data on intensity, for example in the Universal Soil Loss Equation. Alberta has not had an extensive network of recording gauges so data are limited on this aspect of our rainfall. Limited data suggest that, relative to many other parts of the world, our intensities are not high. The greatest amount of rainfall recorded in a 24-hour period at Edmonton is 114 mm, at Calgary 95 mm and at Lethbridge 93 mm. Many locations in the United States have recorded over 250 mm and the record is 388 mm. The world record is over 1100 mm.

Since here in Alberta the total rainfall in a month at any one location averages less than 120 mm it is obvious that there are few intense rainfalls. Intensity of rainfall will be mentioned again in discussing water erosion.

Another special feature of Alberta's climate is the frequent occurrence of hail storms, mainly in the Calgary - Red Deer - Drumheller triangle. These cause severe damage every year and attempts have been made to reduce their severity by cloud seeding, using both aircraft and ground generators. Intense rainfalls are often associated with the hail storms which track across the landscape in bands a few kilometers wide and extending for 80 kilometers or more, usually in a west to east direction. Tornadoes occur in the province, but because of sparse settlement often go unnoticed. A severe tornado struck part of Edmonton in July, 1987.

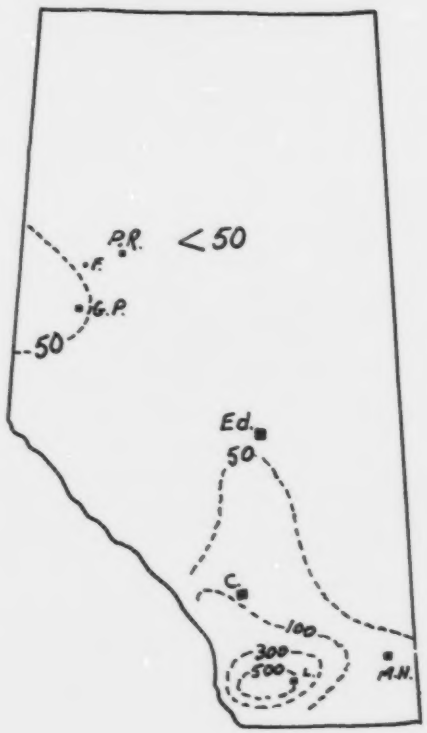
The frost-free period (116 days at Grande Prairie, 105 at Edmonton, 112 at Calgary, and 116 at Lethbridge) is long enough for production of wheat, barley, rye, oats and canola, too short for present soybean varieties, and hardly long enough for corn in the Lethbridge, Brooks and Medicine Hat areas. Winter wheat does well in the Lethbridge area. Many forage crop species, both legume and grass, do well in Alberta. Alfalfa is common. In the Brown and Dark Brown soils few legumes can be successfully grown or included in crop rotations because of moisture shortage. Under irrigation in southern Alberta a great variety of specialty crops are grown, including sugar beets, potatoes, field beans, and fresh and processed vegetables.

Snow cover in winter varies from very little up to about 50 cm. In the chinook belt snow cover rarely lasts through the winter. The nature of the snowmelt in the spring and soil conditions determine how much water and soil is lost in run-off.

The accompanying map shows the hours per year of winds with velocities over 51 km/hr. The area west of Lethbridge shows over 500 hours a year with at least 51 km/hr winds.

The frequency of such winds falls off towards Calgary. In the rest of the province such winds occur for only about 50 hours a year on the average. The high velocity winds in the Lethbridge area are associated with the chinooks and wind velocities as high as 171 km/hr have been recorded there. With such a high frequency of strong winds it is clear why wind erosion in southwestern Alberta is a serious problem.

Wind frequency in Alberta
Hours per year with velocities over 51 kph (32 mph)



Another gauge of the wind erosion risk is the number of days per month on which winds exceeding a given velocity are recorded. The following table illustrates this point with some data from a 4-year study in 1955-58.

Days per month with winds over 16 km/hr at 30 cm height

	Apr.	May	June	July	Aug.
Near Gr. Prairie	3	5	1	3	2
Edmonton	8	15	11	7	6
Calgary	19	19	18	16	13
Lethbridge	17	18	17	11	12

The table confirms the much higher frequency of erosive winds in southern Alberta when compared with the northern parts of the province. Wind velocity will be discussed in more detail in the section on wind erosion.

The Soils of Alberta

With the exception of the Cypress Hills area in south-eastern Alberta practically all of the province was glaciated. The parent materials left by the retreating ice were mostly glacial till, with interspersed areas of lacustrine, alluvial, or aeolian deposits and sandy areas. As the glaciers moved off the Laurentian Shield and over the plains they crossed limestone outcrops, grinding them up with local sedimentary derived material. As a result nearly all glacial tills in Alberta are moderately fine-textured and calcareous.

Deglaciation was largely completed by 12000 BP, and in the extreme northeast by perhaps 10000 BP. It is thought that a sparse forest may have been the first vegetation but this quickly gave way to grasslands as the ice receded. A warm period developed about 7000 BP, followed by the present climatic conditions. By 4000 BP the vegetation zones were more or less as seen today, and soil development reflects these vegetation-climate environments.

Under grass cover the thick humus-rich surface horizons of the Chernozemic soils were developed. The main differences as one goes from the semiarid shortgrass prairie to the subhumid parkland are that the surface color changes from brown to black, the organic matter content increases from about 3 to 10% (2 to 6% in the cultivated state) and the depth of profile increases from about 30 cm to about 70 cm. These prairie soils are among the most naturally productive in Canada.

The other major kind of mineral soil development was the leached or gray surface soils found under the Boreal forests. Here, the increased precipitation efficiency and the slightly acidic decomposition of the leaves resulted in the downward leaching of organic matter and clay into the subsoil. This produced the Luvisolic (Gray Wooded) soils, so prevalent in forested western Canada. These soils, with low organic matter contents and poor surface structure are not as productive as the Chernozemic soils.

There are two other important soil types in Alberta which are not directly related to climate. One is the salt-affected or Solonetzic soils. These are soils with dense subsoils formed from saline materials and common in the grassland regions. The subsoils restrict water and root penetration, thus resulting in loss of moisture by evaporation. A second soil type results from impeded drainage. This is particularly noticeable in the forested areas where sedge and moss peats have developed to form organic soils. These soils tend to be quite cold and in northern parts of Alberta permafrost (a permanently frozen subsoil) is common.

A Chernozemic soil profile, developed under grassland vegetation.

A Luvisolic soil profile, developed under forest vegetation.

The accompanying map shows the ecoregions of Alberta (except for the Cordilleran region). Table 1 shows the key plant species and the soils associated with each ecoregion. It will be noted that the Alberta portion of the Palliser triangle corresponds roughly with the grassland ecoregions listed in the table and shown on the map as Ga2, Ga1 and Gs. Among the Boreal ecoregions mapped it is only the lB (low Boreal) one which has a significant amount of agricultural development. The mB, hB and cB regions contain the province's main forest industries.

Ecoregions of Alberta

(Modified from Strong and Leggat, 1981)

Key — See Table 1

Solonetzic Soils

Table 1 Vegetation and Soils of Alberta

Unit	Ecoregion	Key Species	Soils
Ga2	Arid grasslands (Shortgrass prairie)	Spear and Grama grasses	Br. Chernozemic, Solonetzic
Ga1	Arid grasslands (Mixed grass prairie)	Spear, Wheat & Grama grasses	D. Br. Chernozem, some Solonetzic
Gs	Semiarid grasslands (Fescue prairie)	Fescue and Oatgrass	Black Chernozemic
Gt	Transitional grassland (Aspen parkland)	Fescue, shrubs, Aspen bluffs	Bl. Chern. & some Solonetzic
lB	low Boreal (deciduous and mixed wood)	Aspen with some White Spruce	Gray and Dark Gray Luvisols
mB	mid Boreal (mixed wood boreal forest)	Aspen, White & Black Spruce	Gray Luvisols, Organics
hB	high Boreal (coniferous boreal)	White and Black Spruce	Gray Luvisols, Organics & Cryosols
cB	cordilleran Boreal (foothills Boreal)	Aspen, Pine, Spruce & Birch	Gray and Brunisolic Gray Luvisols

The following table shows a comparison of climatic conditions in the shortgrass and the aspen parkland ecoregions:

Climatic Feature	Shortgrass	Aspen Parkland
Mean annual precipitation	340 mm	450 mm
May - Sept. precipitation	210 mm	300 mm
Moisture deficit	-300 mm	-160 mm
Mean annual temperature	4 C	2 C
May - Sept. temperature	15 C	13 C
Growing degree days	1570	1260
Frost-free period	115	95

Those familiar with the United States system of soil classification may find the following table helpful in studying our Alberta soils, which are classified according to the Canadian system:

Canadian name	Taxonomic equivalent in U.S.A.
Chernozemic	Mollisol
Luvisol	Alfisol
Solonetz	Natric Great Group
Organic	Histosol
Brunisol	Inceptisol
Regosol	Entisol
Cryosol	Pergelic subgroups

Soil surveys were begun in Alberta in 1920, when the University's Soils Department, the provincial, and federal governments cooperated in a study of the soils in the area northwest of Lethbridge. The survey was prompted by the problems of soil management, particularly regarding wind erosion, which were then apparent in the area. Later, as homesteaders moved into the forested regions of Alberta, the need for prior soil surveys and for research on soil management was recognized.

The Soils Department began important soil management studies on Gray Luvisolic soils at Breton in 1930.

The federal Research Stations at Lethbridge, Lacombe, and Beaverlodge were, and continue to be, all engaged in research on soil management. The provincial Extension services of the Department of Agriculture, and the Department of Extension at the University, have a long history of trying to help farmers with soil management problems.

Agricultural Land Use in Alberta

The early homesteaders put into practice methods of farming with which they had been familiar in their homeland. It took several decades to discover better ways of farming, more adapted to conditions in Alberta. The major problems they encountered were:

The moldboard plow. This implement was used commonly until the error of burying all crop residues was realized. Especially was this the case in the Brown and Dark Brown soil zones. First the plow gave way to the disc plow, and then the one-way discer. These plows only partially buried the residues. Then tillage equipment such as rod weeders, duck-foot cultivators, cable weeders and blade weeders appeared on the scene, all aimed at better weed control while leaving trash on the soil surface.

Summerfallowing. The value of summerfallowing in the Palliser triangle, (letting the land lay idle for a season while keeping weeds under control in order to store soil moisture for the succeeding crop) had been discovered in 1886. In the dry regions of Alberta it became customary to fallow every other year, in more humid areas every third year. The risk of wind erosion from such a practice was increased by the mistaken idea that a farmer was doing a good job of fallowing if his land was "black and free from trash". ("Trash" includes both crop residues and weeds.)

Dust mulch. About 1900 the practice of producing a dust mulch on the soil surface to conserve moisture was proposed. This was unwise in areas where wind erosion was a serious hazard and had to be abandoned.

Tractor Power. During the 1920s and 1930s horse power on farms gradually gave way to tractor power. This led to bigger machinery, larger fields, elimination of bluffs of trees or shelterbelts and more rapid tillage. More wind erosion was a result.

Harvesting methods. Harvesting methods began to change in the 1920s and 1930s too. The binder and threshing machine gave way to the swather and combine harvester. This introduced an important factor - with the new method of harvesting most straw and trash were returned to the soil and the soil's organic matter content was increased. Also, there was more trash left on the soil surface to help in the battle against wind and water erosion, provided the farmer did not burn his stubble.

Crop Varieties. Early varieties were at first not well adapted to Alberta. Crop breeders soon produced new ones which were suited to the shorter growing season, were more drought resistant, resisted attacks from rust and sawflies, and were better yielders.

Irrigation. The use of irrigation, which began in the 1880s with the early settlers in southwestern Alberta, made possible higher yields and a greater variety of crops. Farmer irrigation schemes gave way to private companies and these in turn were replaced by government-assisted Irrigation Districts. By the 1980s almost 400,000 hectares were irrigated in Alberta, more than in any other province, and 75% of the total irrigated land in Canada.

As settlement in Alberta moved into parkland and forested regions land use practices were modified to fit the different climatic conditions and

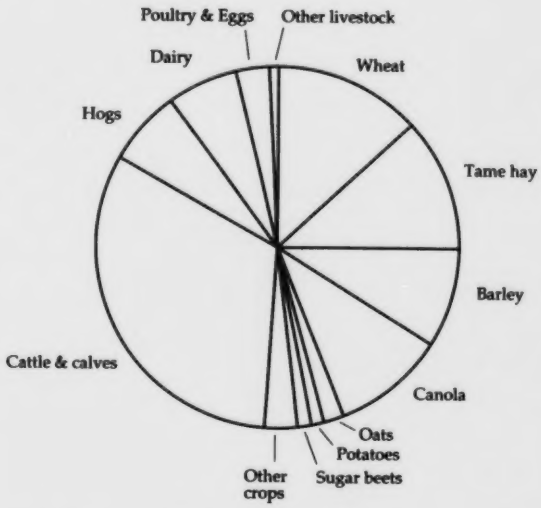
different soils. From mainly grain production, irrigation and ranching in the drier areas farming changed in the more humid areas to mixed farming with livestock and grain production combined. Changes in the market place, development of new crops and varieties, all led to changes in farming methods and crops and livestock produced. Introduction of herbicides and pesticides, together with commercial fertilizers, have now made continuous cropping possible in all but the driest areas of Alberta.

Crops grown on irrigated land in 1987 were:

Soft white wheat	37 % of area
Alfalfa	19
Barley	16
Tame pasture	5
Oilseeds	5
Other wheat	5
Specialty crops	5
Corn (grain & silage)	3
Sugar beets	3
Potatoes	2

In 1987 the gross farm value of agricultural production in the province may be shown by a pie diagram to illustrate the relative importance of the various uses of our farm land.

Pie Diagram showing relative value of agricultural products

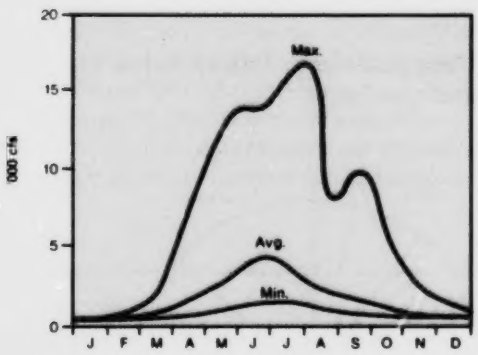


Water Resources of Alberta

Rivers in Alberta drain eventually into the Arctic Ocean, Hudson Bay or the Gulf of Mexico. The Slave River, with its tributaries the Peace and Athabasca Rivers, and the Hay River, flow northward out of Alberta, carrying over 85% of the total flow of all of our rivers; the Beaver, North Saskatchewan, Battle, Red Deer and South Saskatchewan drain to the east into Saskatchewan and account for most of the rest of the flow; the Milk River, a tributary of the Missouri, carries a small flow into the Mississippi drainage basin. The map shows, by the "width" of the rivers the relative amounts of flow, and depicts clearly our water resource situation - the bulk of our water is in northern Alberta, flowing towards the Arctic Ocean while the bulk of our people and our irrigation needs are in the southern part of the province. The southern half of the province has about 15% of the total water supply but 80% of the total water demand.

It is estimated that 80-90% of Alberta's water originates in the mountains and foothills. Of particular interest are the flow regimes of the rivers of southern Alberta - the Red Deer, Bow, Oldman, St. Mary, and the South Saskatchewan. These are the river systems on which the cities of Red Deer, Calgary, Lethbridge, and Medicine Hat depend and these are the rivers from which water is diverted for Alberta's irrigated areas. All of these rivers have their sources in the Rocky Mountains and depend on snow melt and rainfall for their flows. Generally the rivers have peak flows in June or July and minimal flows in January or February. Peak flows fluctuate widely, depending on the mountain snow pack and temperatures and rainfall. A graph showing the monthly flow in the Red Deer River at Red Deer illustrates flow variability. Where storage and power dams have been built there is some control of flow rates in downstream locations.

Flow Regime of Red Deer River at Red Deer



Flow Regime of Red Deer River at Red Deer.

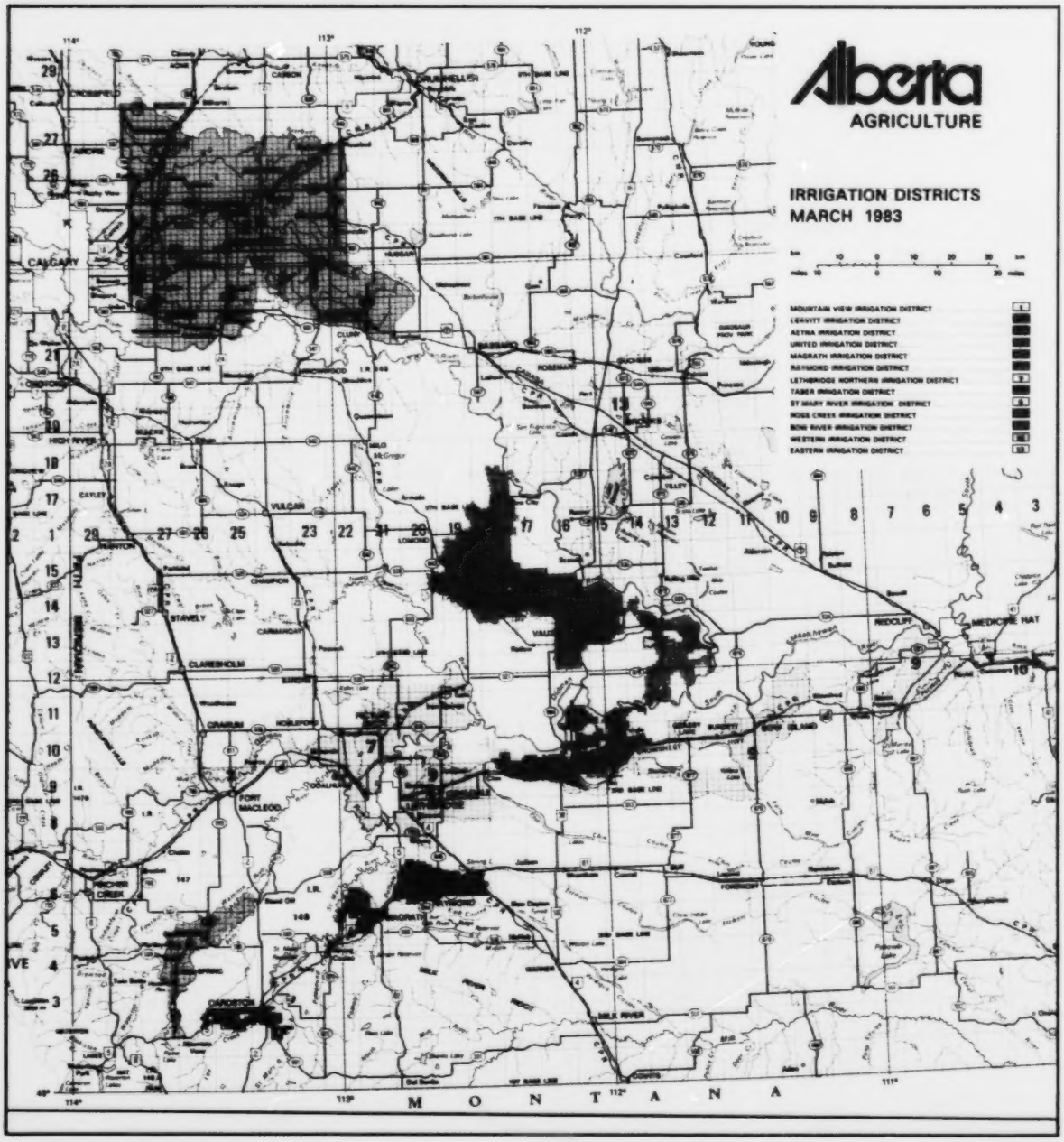
Interprovincial agreement requires that half of the total flow of the Red Deer and South Saskatchewan Rivers must pass into Saskatchewan. Thus all the water diverted for irrigation, cities and towns must still leave half the flow to move on to that province. At present from 60 to 80% of the flow passes into Saskatchewan but existing and planned on-stream storage dams and reservoirs will aid in storing the peak flows and balancing the supply in the region.

The map on page 13 shows locations of dams, reservoirs, major canals, and irrigated districts.

In addition to rivers, groundwater is an important source of water for Albertans living in most rural areas. There are some areas of the Peace River region where dugouts must be relied on for domestic water supplies. Groundwater is not a significant source of water for irrigation purposes.

Mean Annual River Discharges

Irrigation Districts March 1983



Produced by Provincial Mapping Section, Land Information Services Division © 1988

Water Use in Alberta

Irrigation is a large user of water compared to domestic use in cities and towns, with irrigation using about 90% of the water diverted from rivers. Thus any expansion of irrigated areas in southern Alberta has to face the question,"Will there be enough water?" The present irrigated area (about 400,000 hectares) is already using a large proportion of available water in an average year, and when rainfall is below normal, critical shortages may occur. Improvements in storage capacities and in water use efficiency would make possible an expansion in the irrigated area, the upper limit now being estimated at about 800,000 hectares.

Centre pivot irrigation system in operation.

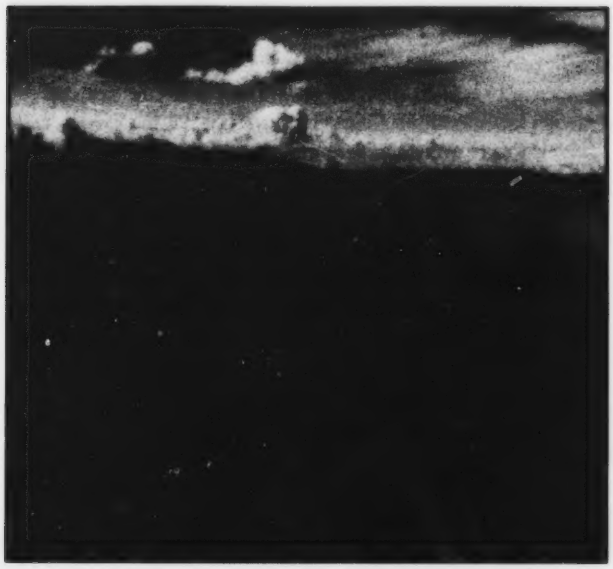
The apportionment of flow in the Red Deer and South Saskatchewan Rivers is made after the rivers join inside Saskatchewan. Since little water is diverted from the Red Deer compared to the other tributaries of the South Saskatchewan it is possible to use the Red Deer to make up for diversions from the other rivers to ensure that half the total flow reaches Saskatchewan.

Very little groundwater is available for use in large scale irrigation projects in Alberta. There are small schemes however, set up and operated by individual farmers and gardeners, using groundwater. In addition to such small scale irrigation projects a large amount of groundwater is used to supply water for towns, villages, industries (particularly the petroleum industry) and for farm homes and livestock watering. In some of these cases it is possible to recycle much of the water and thus reduce the amount that has to be removed from the groundwater reservoir.

Water for domestic use in Alberta is in general plentiful. Nevertheless some city dwellers have their water metered and pay for water used. On rare occasions, after an excessively long dry period or when the river flows are very low, there has to be some rationing of water.

Alberta rivers generally have good quality water with a minimum of suspended material in most locations. However, water quality usually deteriorates at the time of spring breakup and during big flood events. This is due to large quantities of suspended mineral and organic material washed into the rivers. Also, as rivers flow through agricultural areas and through cities and towns their quality deteriorates as they pick up run-off carrying eroded materials and wastes.

Water is obviously an important natural resource with many uses, such as for power generation, in industry, for recreation, and for support of wildlife. The government has special branches devoted to conservation of water for such purposes. This story is focusing on conservation of water in agriculture.



A fence row near Lethbridge filled with drift soil and a badly eroded field.

Wind Erosion in Alberta

History

Wind erosion occurred in Alberta long before the prairie grasslands were plowed. Eroded pits dotted the landscape, especially in areas of solonetzic soils. In these spots bisons wallowed and loosened the surface soil and the winds then blew it away down to the depth of the hardpan. It was after the settlers moved in however, and plowed up large areas of native sod, that wind erosion became extensive and the problem came to the attention of farmers.

In the chinook belt of southwestern Alberta, and especially in the Brown and Dark Brown soil zones, wind erosion began to demand attention. By 1914 the problem was recognized and causing grave concern. The use of the moldboard plow, the practice of black summerfallowing (leaving no plant material on the soil surface), stubble burning, and the use of dust mulches to conserve moisture were all encouraging wind erosion. In 1917 soil drifting was so severe in southern Alberta that whole fields lost their topsoil and ditches and fence-rows filled up with drift soil.

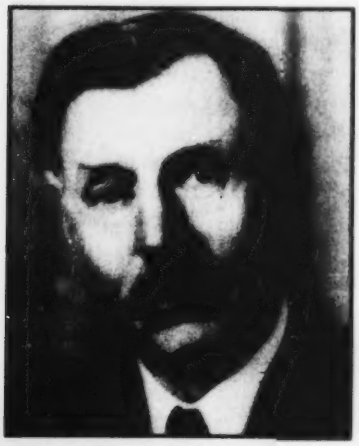
The Agriculture Canada Research Station (then called an Experimental Farm) at Lethbridge gave special attention to wind erosion, and in 1921, when A.E.Palmer was appointed assistant superintendent, he gave the problem his full attention. He had already in 1920 observed the value of crop residues in stopping wind erosion. He travelled widely, discussing erosion problems with farmers and evaluating the control measures being attempted. Some farmers were experimenting with plowless fallow and finding it helpful. Farmers in the Monarch area, west of Lethbridge, were trying strip farming, others were experimenting with various implements to increase the roughness of the soil surface or to leave more trash on the surface, and others were trying cover crops seeded in late July or August on fallow land. All of these measures helped, especially the practices of strip farming and maintaining trash cover on the soil. Palmer's efforts in spreading the word among the farmers in southern Alberta were praiseworthy.

Dr. A. E. Palmer. (From the Provincial Archives of Alberta: Archives Collection A7429.)

The years 1931 to 1937 were marked by unusually low rainfall in southern Alberta and crop yields were very low. This meant that there was little production of straw and thus a trash cover was difficult to maintain. Coupled with this were high velocity winds that swept across the land creating "black blizzards", hence the name "dirty thirties". Even in irrigated areas where fine seed beds were prepared for specialty crops, and before water was applied, serious drifting occurred.

The whole of "Palliser's triangle" was affected and the term "dust bowl" was used to describe the situation. Low prices for farm products and heavy infestations of grasshoppers, sawflies, and cutworms, added to the burdens carried by the farmers. In fact many farms were abandoned and on others life was at a subsistence to starvation level.

But more help was on the way. The Prairie Farm Rehabilitation Act was passed in the federal parliament in 1935 and gave rise to the Prairie Farm Rehabilitation Administration (PFRA). Under the PFRA federal research centres and their sub-stations were assigned the task of saving the soil. In southern Alberta twelve sub-stations of the Lethbridge station were established to demonstrate good soil conservation practices. The PFRA led to the organization of Agricultural Improvement Associations, which organized meetings of farmers to publicize the best methods of erosion control. Much of the work centred on reclamation of areas in the Brown and Dark Brown soil zones where farms had been abandoned. This led to procedures for re-establishing grass cover, organization of community pastures, establishment of shelterbelts, and water conservation measures such as the construction of dams and dugouts. These programs are still in place today.



Dr. C. S. Noble. (From the Provincial Archives of Alberta: Archives Collection A2275.)

A major step forward was made by C. S. Noble. This innovative farmer, after whom the town of Nobleford is named, devised and built a blade weeder in 1935. This implement, which several farmers at the time were attempting to build, was the solution to the problem of how to kill weeds in fallow and still leave the stubble standing. The Noble wide blade cultivator was soon in mass production and sold widely on the prairies, in the United States and overseas. At first a straight blade, this was later replaced by a wide V-shaped blade. Other manufacturers have produced similar implements of slightly different design. The blade type of cultivator presents problems in some fine-textured soils at critical moisture levels but does an effective job of leaving the trash on the surface. Adjustments of the blade are critical in fine-textured soils.

A group of Noble blades on display and ready for some conservation tillage.

The term "trash cover" was used by Dr.A.E.Palmer to describe any plant residue, whether grain stubble, dead weeds, straw or any kind of trash left on the soil surface and forming a protective cover. Extension workers now prefer the term "crop residue". In this story "plant residue" will be used to make clear that any plant material, whether from crops or weeds, can form a protective cover.

By the late 1930s the problem of soil drifting in the chinook belt was largely under control, provided strip farming was practiced and plant residues kept as cover. The period of dry years ended and black blizzards became less common.

Meanwhile in other areas of Alberta the problem of wind erosion was not tackled and dust

clouds continue to be a common sight. In spite of heavier rainfall and lower frequency of high wind velocities, and because of highly mechanized farming and ever larger fields, wind erosion continues, with farmers taking few precautions. Continued use of the moldboard plow and double disc by some farmers, thus burying all the plant residues, and with no attempt at strip farming and no attempt to use a continuous cropping system,- such practices continue to result in wind erosion every year. As recently as 1988 a black blizzard occurred a few miles east of Edmonton (see cover picture).

Research on Wind Erosion

The Lethbridge Research Station has naturally been active in studying various aspects of wind erosion. In addition to A.E.Palmer other scientists there who have studied the problem include D.T.Anderson, H.Chester, J.T.Dormaar, C.W.Lindwall and A.D.Smith. The following aspects of the problem have been studied and continue to receive attention:

1. Straw/grain ratios of various crops and effect of weather on this ratio,
2. Amount of plant residue left on the surface by various types of tillage implements (See table 2),
3. Seeding equipment for residue-covered fields,
4. Width of strips for strip cropping to control erosion on soils of various texture (See table 3),
5. Tillage procedures, including minimum and zero tillage,
6. Topsoil losses and their effects on productivity,
7. Management practices to restore productivity,
8. Cover crops for erosion control,
9. Emergency wind erosion control measures, and
10. Soil drifting on irrigated land.

Table 2. Amount of plant residue left on the soil surface after tillage by various implements

Implement used	Residue left
Moldboard plow	Nil
Discer (with 24" pans)	50%
Heavy-duty cultivator (16" shovels)	80
Rod weeder	90
Wide-blade cultivator	90

Table 3. Width of strips for wind erosion control

Soil texture	Maximum width
Fine sand, fine sandy loam and heavy clay	25 m (82.5 ft)
Silty clay	50 m (165 ft)
Loam, silt loam	80 m (255 ft)
Clay loam, silty clay loam	100 m (330 ft)

Important research on the dynamics of soil movement by wind was done by W.S.Chepil at the Swift Current Research Station in Saskatchewan. He used wind tunnel procedures in the laboratory and in the field to study wind movement of soil particles in suspension, by saltation, and by surface creep and the effects of trash in stopping such movement. Research on width of strips necessary to prevent wind erosion was also studied at the Swift Current Station.

Strip farming for wind erosion control.

The soil drifting problem in the chinook belt stimulated the first soil surveys in Alberta. In 1921 the Soils Department of the University of Alberta, with cooperation from provincial and federal governments began a soil survey of the Macleod Sheet, an area northwest of Lethbridge. The mapping of the soils was based largely on the texture of the surface soil. In later years the Soils Department had graduate students work on wind erosion. R.L.Erdman reported on the effects of wind erosion on the composition and fertility of soils; S.Ibrahim studied the damaging effects of wind erosion on soils; the author reported in 1971 on the amount of strip cropping done in southern Alberta, noting that very little was done north of Vulcan and also that in many cases strips were wider than recommended; the author also published in the University's Agriculture Bulletin in 1973 a pictorial history of dust storms in Alberta and a warning of the possibility of more to come.

The provincial Department of Agriculture, while concentrating on extension work in the early years, has recently become involved in research on soil conservation. In 1983 K.K.Krogman prepared for the Soils Branch an "ANNOTATED BIBLIOGRAPHY ON SOIL EROSION BY WIND APPLICABLE TO SOUTHERN ALBERTA". This lists 136 references to research reports and presents Krogman's review of the research. An important survey was completed in 1988 at the instigation of the Alberta Conservation Tillage Society by Alberta Agriculture among 549 Alberta farmers, many of whom farm in southern Alberta, to check on their use of conservation tillage practices, crop rotations used, and amount of soil losses due to erosion.The report of the survey indicates the lack of appreciation among many farmers of the serious aspects of soil erosion.

The PFRA, while not a research organization, has continued to facilitate and augment studies in soil and water conservation and development.

Legislation Relating to Wind Erosion

Alberta's black blizzards of the 1920s and 1930s, along with wide publicity given to similar dust storms throughout the Palliser triangle and the central plains of the United States, prompted efforts by the provincial government to halt the devastation. This was in keeping with the principle that as of 1930 the federal government had granted Alberta control of its natural resources, and a paramount resource of any state is its soil.

In 1935, the year the federal government passed the Prairie Farm Rehabilitation Act, the provincial government passed the Soil Drifting Control Act. The committee recommending the legislation wanted to see farmers penalized if they permitted their soil to blow by neglecting to follow preventive practices. The legislation was contentious and the penalty clause was substantially reduced in the final draft of the Act. The Act was administered by the Department of Agriculture and a few cases were brought into court. The penalty provided for in the Act however was never imposed.

The Special Areas Act, with enactments in 1927, 1931, 1935, and 1938 was administered by the Department of Municipal Affairs. This legislation sought to cope with the problems of over-settlement, drought, soil erosion and economic land use in Alberta's drought area. In 1953 the Act authorized the Minister "to order and require any owner or occupant of lands to adopt such methods of farming or grazing as may be deemed necessary to prevent soil drifting or over-grazing".

The Public Lands Act of 1955 was administered by the Department of Lands and Forests and set out provisions under which Crown lands should be recorded, classified, leased or sold. The practice of the Department was to have lands inspected and placed in reserve if there was a wind erosion risk. This Act is now administered by Alberta Forestry, Lands and Wildlife.

The revised Agricultural Service Board Act of 1955 was administered by the Department of Agriculture. It sought to assist municipalities in projects such as soil erosion control, weed control, rehabilitation of tax recovery lands, etc. It established cooperative efforts between the Department and the Agricultural Service Boards of the municipalities in such efforts as the following:

a) Wind erosion control demonstrations,
b) Contour or strip farming,
c) Reclamation of soils damaged by erosion or salinity,
d) Shelter belt planting,
e) Extension work aimed at stopping wind and water erosion,
f) Soil conservation area programs, and
g) Farmland development and reclamation programs.

In 1962 the Act Respecting Soil Conservation was passed. This required each county or municipality to appoint a Soil Conservation Officer. While land holders were expected to prevent erosion the Officer could demand that steps be taken to stop erosion resulting from poor farming practices. Provisions were made for penalties to be imposed on land holders who allowed erosion to occur. Again, as with the Soil Drifting Act of 1935, there have been very few prosecutions under this Act.

The Soil Conservation Act of 1962 was updated in 1980 and again in 1988 to strengthen the powers of a municipality or county in ensuring good conservation practices in their areas. The 1988 Act provided for the appointment of provincial Soil Conservation Officers as well as the municipal Officers. The goals were:

1) To encourage sound conservation practices,
2) To preserve Alberta's agricultural land base, and
3) To sustain levels of agricultural productivity.

A problem, to be discussed later, is the one, "Who should pay for soil conservation practices?" Society wants the soil protected for future generations. Should the farmer be expected to bear the full cost of practices necessary to protect the soil? If the farmer is put to additional expense of time and trouble to use narrow strips, trash cover farming, and/or emergency measures, should he not be assisted in some way by society at large? Why should he carry the whole load?

Non-Government Organizations and Soil Erosion

A number of professional organizations have given their attention to soil erosion problems, notably the Alberta Institute of Agrologists, the Agricultural Institute of Canada and the Alberta Chapter of the Soil and Water Conservation Society (formerly the Soil Conservation Society of America). Farmers groups have also been organized, such as the Alberta Conservation Tillage Society and the Dryland Salinity Control Association, both of which have published their goals and objectives.

The Alberta Institute of Agrologists at its annual meeting in 1959, noting that wind erosion had been serious in the spring seasons of 1957 and 1958 and that progress in its control was slow, appointed a committee to "review and report on the present condition of our soils from an erosion position, the attitude of farm operators toward control programs, the effectiveness of control legislation, and the possibilities of maintaining and improving our soils." The committee appointed consisted of Dr.A.E.Palmer, C.A.Weir, and Dr.O.S.Longman, men who had had a lengthy experience with erosion problems in the province.

The committee submitted their report in 1961 to the A.I.A. The review of government legislation given earlier in this story is based largely on their report.

Their report included the results of a survey conducted among District Agriculturists, Municipal District Agricultural Service Board Supervisors, other government officials and selected farmers. The results pointed to the fact that while wind erosion was still damaging some soils in the chinook belt there was a great deal of erosion in the areas east and northeast of Calgary where farmers were not following cultural practices to stop wind erosion. Large fields, no strip cropping, excessive use of fallow, burying or removal of plant residues, and little use of emergency measures were all resulting in frequent dust storms. The Drumheller area reported 120,000 to 140,000 hectares damaged by wind erosion in 1959. Many farmers were simply not heeding the advice of District Agriculturists or Agricultural Service Board Supervisors, who were all very much aware of the problems and anxious to provide help.

The report to the A.I.A. urged continued research and concluded with these statements: "The

soil is agriculture's foundation. It is the function of agriculturists to bring the soil and man into a mutually beneficial relationship, each sustaining and preserving the other. Therefore no department of agriculture can succeed in this task unless it is intimately associated with both the land and its occupant. Trusteeship is a prerequisite to this accomplishment. It is at this point that most authorities agree that a form of land tenure compatible with the continuing stability of the soil must be found."

The Agricultural Institute of Canada is the national organization of professional agrologists. In a determined effort to publicize the need for soil conservation the A.I.C. in 1984 published "Will the Bounty End?" by G.L.Fairbairn. While the 160-page book deals with several aspects of agriculture in general it concentrates on "grim warnings about the hidden economic and environmental disasters awaiting a nation that neglects its land resources." While the author received help from agrologists across Canada and made use of research reports and published scientific literature, much credit goes to Dr.A.A.Guitard, President of the A.I.C. 1982-1983, who was largely responsible for the publication. The book includes a lengthy literature review and there are numerous references to wind erosion in Alberta.

A federal government publication, "Soil at Risk", also published in 1984, was prepared for the Standing Senate Committee on Agriculture, Fisheries, and Forestry. The purpose of this 130-page book was "to take the reader on the equivalent of an airplane ride over Canada to make clear what soil degradation is and how serious it is in all regions of the country." Many agrologists provided information for this publication. Both wind and water erosion are reviewed, the section on wind erosion on the prairies describing the degradation of the soil that results.

The Soil and Water Conservation Society, a 13,000-member organization, now has a Chapter in Alberta. The SWCS publishes a bi-monthly Journal, reporting on current research on wind and water erosion problems, soil degradation, pollution problems, and conservation methods. The Alberta Chapter was organized in 1981, allowing Alberta members of the Society to coordinate their interests in provincial problems. It now has over 120 members and seeks through its meetings and public relations to arouse more interest in soil and water conservation in Alberta.

Several farmer groups have been organized to foster soil conservation. These include: Alberta Conservation Tillage Society, Dryland Salinity Control Association, Sustainable Agriculture Society, Chinook Applied Research Association, Battle River Applied Research Association, Smokey Agricultural Research and Development Association, as well as various Forage Associations.

Many Agricultural Service Boards have organized soil conservation workshops, which have contributed substantially to "spreading the word". These have brought together agriculturists, hydrologists, and wildlife biologists along with local political bodies and farmers to help generate the coordinated approach that is so important to land use and conservation in the broadest sense.

Control Measures for Wind Erosion

Wind erosion is Alberta's most serious erosion problem, and therefore warrants a full discussion of control measures. In his "Annotated bibliography on soil erosion by wind applicable to southern Alberta", referred to earlier, Krogman included an excellent review of current thinking on how to stop wind erosion. Numerous quotations follow with a few comments added.

"Preventive measures are based on eliminating the causal factors...They include maintaining a non-erosive condition of the soil itself by keeping a cloddy structure at the soil surface....Spring-tooth cultivators or chisel cultivators are examples of implements to do this....Disc harrows, and particularly drag harrows should not be used because these machines pulverize the soil.

"Prevention of wind erosion is also achieved through protection from the wind. Trash cover on uncropped land consisting of stubble, straw, etc. on the surface protects the soil. During the off-crop season only sufficient cultivations should be done to control weeds, using machines that do not bury all the stubble and straw.....

Good trash cover prevents wind erosion.

"Living or dead plant material may also provide wind protection. Included here are cover crops (usually an annual crop such as oats, planted in late summer) to provide protection during the critical fall, winter and spring seasons. Also included here are field shelter belts and barrier strips. The barrier strips consist of one or two rows of a tall-growing grass or annual plant such as flax, seeded every 50 to 75 feet (15 to 25 m) across the direction of the prevailing wind. Field shelterbelts and barrier strips reduce the wind velocity for a distance about 20 times their height on the leeward side. In addition to providing wind protection, shelterbelts and barrier strips trap snow which helps to guard against the alternate freeze-thaw and freeze-drying destruction of soil aggregates.

"The practice of strip cropping began in southern Alberta in the late 'teens and by 1930 much cultivated land in southern Alberta was strip cropped. In this system, strips of crop alternate with strips of fallow across the direction of the prevailing wind. The strips must be narrow enough to prevent serious soil drifting from beginning within the width of the strip. Narrow strips (80 to 160 ft, or 25 to 50 m, wide) are required on the more erodible sandy or clay soils. Wider strips (160 to 320 ft, or 50 to 100 m) may be used on less erodible medium textured soils. A combination of strip cropping and trash conservation with blade or cultivator implements on summerfallow will almost certainly provide complete protection against wind erosion. The only exception would be highly erodible soils that should not be used for annual crops and should be left permanently seeded to grass.

"Dealing with the wind erosion problem is somewhat different on irrigated land than on dryland. On irrigated land summerfallow should be unnecessary. All irrigated land should support a crop during the growing season. However, some crops may not provide much wind protection in the

Strip farming in southern Alberta.

spring, and erosion prevention will depend on a roughened, lumpy soil surface. Aftermath of irrigated crops is often fed to livestock in the field and trampling may render fields very erodible. Such fields need to be roughened with a cultivator or chisel cultivator. Where danger of erosion in seedling rows is severe, strips of cereal plantings or barriers have been suggested as preventive measures.

"The primary and most important methods to combat wind erosion are preventive. Where prevention has not been provided or was inadequate, and soil drifting has started, emergency measures must be used to stop further damage." These emergency measures must be carried out promptly, the moment there is a sign of soil eroding.

"Erosion usually begins at "focal" points, or spots where the soil is most easily eroded. Such focal points should be detected early when the drifting can usually be stopped by spreading straw or manure. A light discing may be required to anchor

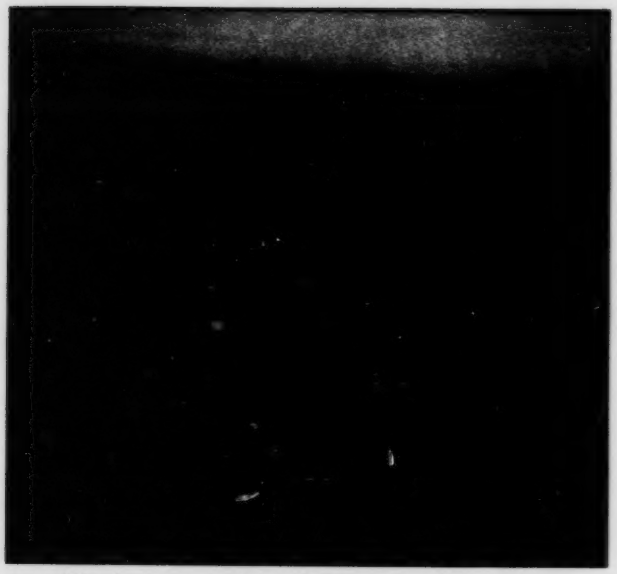
the straw....." Where large areas are starting to drift chisel cultivators, listers, etc. may be required to roughen the soil surface.

"In the past 20 or 30 years the technology of implementing known preventive and corrective measures has greatly improved. This includes the development of large farm machines capable of performing the field operations quickly and effectively, chemical control of weeds and new, more drought-tolerant varieties of grain, particularly wheat and barley.

"Large, powerful machinery allows field work to be done when weeds are most easily killed. High-yielding varieties of crops may produce more straw and stubble, giving more protective trash cover. Herbicides can be used to control weeds without disturbance and destroying of trash cover.

"Herbicides make possible grain farming with only enough cultivation to allow planting the seed. This "minimum-till" or "no-till" method of soil management should almost completely eliminate risk of wind erosion."

However, all aspects of the "minimum" or "zero" tillage systems have not been fully researched in the wide range of conditions in Alberta. The relatively high cost of herbicides and apparent need for more specialized seeding equipment has limited the widespread adoption of "zero tillage" systems. High clearance hoe drills and some specialized "no-till" drills are being used with some success in many areas of the province. Effective air-seeders are also becoming very popular for use in minimum tillage systems. With minimum or zero tillage fertilizer placement is more critical than with traditional tillage systems. Careful attention to detail is vital for success with the various types of conservation tillage.



An eroded gully means valuable topsoil has been lost and is an obstacle to cultivation.

Water Erosion in Alberta

Water Erosion in Alberta

Water erosion in this province has not produced the equivalent of "black blizzards" and so has received much less attention than wind erosion. In the Peace River area of northwestern Alberta water erosion has been noted for years and attempts made to reduce it but in central and southern Alberta little has been done. The major problems arising from water erosion have been the following:

1) Topsoil is lost by sheet, rill and gully erosion, and there is a gradual transport of topsoil downslope by splash erosion. These processes along with wind erosion have led to eroded knolls and upper slopes and reduced productivity.
2) Gullies form in fields and roadside ditches. Deep gullies in fields interfere with farm operations, are a source of weeds, and pose a safety hazard.
3) Roadside ditches, drainage channels, sloughs and streams are filled with eroded materials.
4) Irrigation return flow has been allowed to erode large gullies in some cases.

Valuable water is often lost in spring run-off and from summer rains. Frequently the run-off ends up in low-lying flat areas where it is least needed, and often it also leaves a deposit of eroded soil.

Occasionally there is flooding of some of our northern rivers, notably the Pembina and Athabasca, as a result of heavy spring run-off or exceptionally heavy rainfall. This has from time to time damaged low-lying fields and farmsteads.

Rainfall and Water Erosion

As pointed out in the section on Alberta's climate, total annual precipitation (excluding the mountain areas) is relatively low, varying from 300 mm in the shortgrass area to over 600 mm in the Swan Hills (200 km NW of Edmonton). The growing season precipitation (April-August) in the agricultural areas varies from 175 to 350 mm. Coupled with the problem of low rainfall is its variability, which for growing season rainfall in the Lethbridge area is ±35% and in the Edmonton area ±30%. Thus soil moisture

deficiency, preventing optimum crop growth, is an annual problem in many areas in Alberta. Relative humidity is usually low so rates of evapotranspiration are high. As a result of these climatic conditions Alberta's soils are usually well below field capacity and able to absorb readily most of the low intensity rainfall received.

Coupled with low total rainfall are special aspects of our summer rains relating to water erosion: relatively low intensity, short duration, covering small areas, and occurring mostly in late June or in July when crops are well established and able to give some protection to the soil. The matter of low intensity was discussed earlier.The fact that our heavy rains are of short duration is evident from the figures for total growing season rainfall. Farmers in the Brown and Dark Brown soil zones know only too well how local the summer storms can be and how often their parched crops are missed by a passing storm.

In northwestern Alberta serious erosion often results from snowmelt in the spring. Long, gentle slopes, coupled with fine-textured soils, frequently show signs of sheet and rill erosion after all the snow has melted.

Research on Water Erosion

The aspects of Alberta rainfall described above would seem to point to a low water erosion hazard. It has indeed received little attention from researchers. The author's 10-year research project near Edmonton (1949-1959) compared losses of soil from plots of a Chernozemic soil with 10% slope with grass cover, under wheat-fallow cropping, and under wheat-oats-barley-hay-hay cropping. In the 10-year period there was only one highly erosive rain, occurring July 30,1953, when the rain fell at a rate of 152 mm/hr for 7 minutes. Only the fallow plot suffered. Data on rainfall intensity collected elsewhere in Alberta suggest a similar low risk of high intensity rain at a given site. Data for return periods of heavy rains in the accompanying table illustrate this fact.

Return periods for one day rainfall

Location	Once in 5 yrs.	Once in 25 yrs.
Grande Prairie	49 mm	76 mm
Edmonton	57	93
Calgary	60	96
Lethbridge	51	76

Some research conducted by the University of Alberta's Soil Science Department on physical properties of soils in the Edmonton area studied infiltration rates and water-holding capacities in relation to water erosion. If the infiltration rate exceeds the rainfall intensity there is no run-off and if the water-holding capacity exceeds the total rainfall there is likewise no run-off and no erosion. The research showed that throughout most of the growing season our soils are well below their field capacity and hence able to absorb most of the light showers that occur. Soils with compact subsoils however, such as Solonetzic soils, while able to absorb rainfall for a few minutes until the topsoil is saturated, then show a very low infiltration rate and run-off occurs. Since soils show great variation in texture, in structure, and in profile characteristics there are wide differences in their infiltration rates and field capacities. Soils with compact subsoils are the most likely to have run-off and show signs of water erosion.

It is obvious that saturated soils will not absorb more rainfall. In instances when heavy rains continue for many hours there is bound to be run-off and erosion. Our data on 24-hour precipitation events indicate this is not often the case in Alberta. Fallowed fields however, especially when cultivated up and down the slope, are often seen with signs of rill erosion.

Dr.D.S.Chanasyk, of the University of Alberta's Soil Science Department, has studied run-off and erosion in the Peace River area at the time of spring snowmelt. He and his research assistants found that the majority of soil loss occurred during this period. Between 70 and 90% of the snowmelt occurred as run-off, the subsoil usually being frozen and unable to absorb water.

R.T Heywood of Alberta Agriculture in Lethbridge has done research on snow management, the goal being to increase the efficiency of snow storage. Good snow management results in retention of more snow and reduced evaporation from the soil surface. Tall stubble and alternative height swathing have proven to be the best of the methods tried.

Snowmelt time in the spring and a gully starting to form.

J.Tajek and Dr.W.W.Pettapiece of Agriculture Canada and K.E.Toogood of Alberta Agriculture used a modified form of the Universal Soil Loss Equation (USLE) to calculate and map the water erosion potential of the soils in areas of the province covered by reconnaissance soil surveys and producing cereal crops. Their modified USLE included a snowmelt factor. Their map classifies the potential as negligible, slight, moderate, severe, very severe and extreme. Most of the area mapped by the soil surveys, which includes our agricultural land, falls into the first two categories.

Management Mistakes Resulting in Erosion

The lack of frequent heavy rains at a given site in Alberta leads many farmers to disregard the risk altogether. Sooner or later they get caught by a severe storm and serious erosion occurs. Here are some management practices that lead to problems:

1) Water courses are cultivated. The first heavy rain in years comes unexpectedly and washes away soil, creating a gully.
2) Steep slopes are cultivated and cropped. Sheet and rill erosion wash off the topsoil unless there is adequate crop cover. If the unexpected storm strikes in June while the soil is not well protected there can be serious erosion.
3) Fields are summerfallowed when it is not necessary for conservation of moisture. Summerfallowing may be justified in the Brown soil zone, and sometimes in the Dark Brown soils, but it is not needed in Alberta's Black soils. With no crop residue left on the surface water erosion can occur with rains of relatively light intensity.
4) Fields are cultivated up and down the slope instead of on the contour. Run-off that might have been trapped on the slopes by contour ridges flows down the man-made furrows and valuable water is lost and soil eroded.
5) Some farmers continue to bury all crop residue when tilling their land. This is an open invitation to water erosion and puddling of the soil,

Rill erosion on an unprotected slope.

with nothing left to impede surface run-off. This is also a major problem on irrigated land because of intensive cultivation to prepare seedbeds, especially on sloping land irrigated with center pivot systems.

6) Allowing water erosion to occur may also cause other problems: silting and pollution of streams and rivers, a problem for provincial hydrologists and civil engineers, and for wildlife officers.

THE WATER EROSION PROBLEM IN ALBERTA IS SERIOUS BECAUSE IT IS TO A LARGE EXTENT DISREGARDED BY MANY FARMERS.

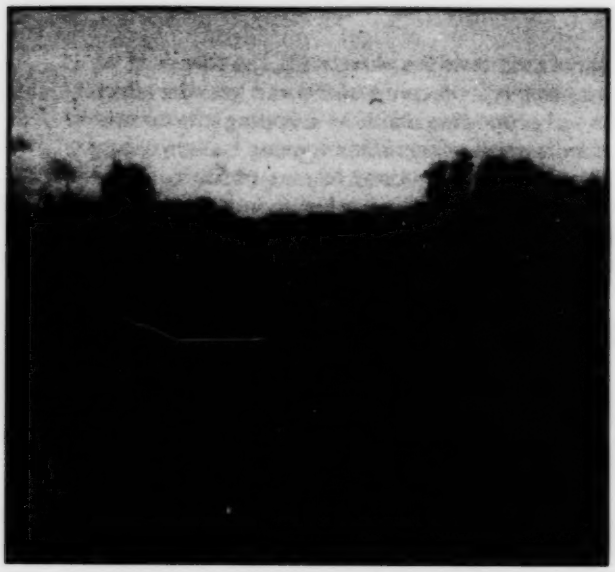
In recent years government departments, notably Agriculture and Environment, have increased their attention to water erosion problems. Both on-farm and off-farm projects have been initiated to increase public awareness.

Control Measures

- Water courses likely to form gullies should be seeded down to grass or grass-legume mixes.
- When summerfallowing, as much crop residue as possible should be left on the surface to form a protective cover for the soil. While this may intercept and prevent very light showers from reaching the soil it will also prevent excessive evaporation of soil moisture, an important water conserving practice.
- Consider contour tillage if the topography lends itself to this practice. It will reduce run-off and give rain a chance to be absorbed by the soil.
- Contour strip cropping has been demonstrated at a number of sites in the province. It could be considered where slopes are long and wide.
- Crop rotations including grasses and legumes not only provide protective cover for the soil but result in an improvement of soil structure and tilth and a chance to build up its organic matter content.
- Not much can be done in most cases to hold back the spring snowmelt, but a tall stubble will trap snow and retard run-off. Fall cultivation is often unnecessary and should be avoided if possible.

** The primary goals should be: conserve soil moisture by preventing run-off whenever possible; stop gullying by using grassed-in water courses; leave sufficient crop residue on the surface to form a protective cover.

Newly seeded watercourse with cover-crop just emerging.



Summerfallowing encourages rapid decomposition and loss of organic matter in soils.

Other Forms of Soil Degradation

Many soils in Alberta have been degraded from their virgin state as a result of farming operations. This has occurred especially in the Brown, Dark Brown, and Black soil zones, where two types of degradation have been noted in addition to wind and water erosion.

Organic Matter Losses

The virgin grassland soils of Alberta contained from 2 to 10% organic matter in the Brown and Black soils respectively. Cultivation, and especially the practice of summerfallowing, has resulted in an increased rate of decomposition of organic matter and these soils now contain only 50 to 65% of the organic matter they contained in the virgin state. The practice of removing the straw from the fields, as in the days of the binder and threshing machine, gave the soils no chance to regain their organic matter content and they showed a steady decline. Modern swathing and combining techniques, with all crop residues returned to the soil, have halted the decline, and may even increase organic matter levels. If, however, the straw is baled and removed there is little crop residue left to protect and improve the soil.

The emphasis on grain crop production or continuous oilseed production has also had a degrading effect. To maintain an adequate level of organic matter levels requires crop rotations including grasses and legumes, not always feasible in the Brown and Dark Brown soil zones, or intensive grain crop management to ensure that large quantities of crop residues are returned to the soil. Economic factors are often a primary consideration, for example where a farmer decides to bale his straw and sell it off the farm. Straight grain farming, with no livestock, means farmyard manure is not available for field application. Manure helps to maintain high organic matter levels in soils. The value of alfalfa and manure has been demonstrated in long-time cultural experiments at the Lethbridge Research station on a Chernozemic soil.

The Luvisolic soils, in contrast to the Brown, Dark Brown and Black Chernozemic soils, are initially very low in organic matter when the land is cleared and the soil cropped. Here the low levels of organic matter result in poor structure and tilth and poor crop growth. The level can be increased by crop rotations including grasses and legumes. This has been demonstrated at the Breton Plots. These plots, established by the University of Alberta near

Breton in 1930 on the farm of Ben Flesher, are located on a Luvisolic soil. The soils on these plots have been improved by a 5-year rotation of wheat-oats-barley-hay-hay. Organic matter content has increased and soil physical properties improved with this rotation while a wheat-fallow rotation has given low yields and poor soil tilth. The growth of legumes and grasses requires livestock to utilize the forage crops so a straight grain farming program is not suited to such Luvisolic soils.

The University of Alberta and the Lethbridge Research Station are doing extensive research on the fate of crop residues in our soils, the chemistry of organic matter decomposition and loss, the effects on soil properties, and how cropping practices and manure applications affect organic matter content. This soil constituent is an important source of the plant nutrients nitrogen, phosphorus, and sulphur. It also affects soil porosity, water holding capacity, tilth and erodability. Thus the maintenance of high levels of organic matter is important in soil conservation.

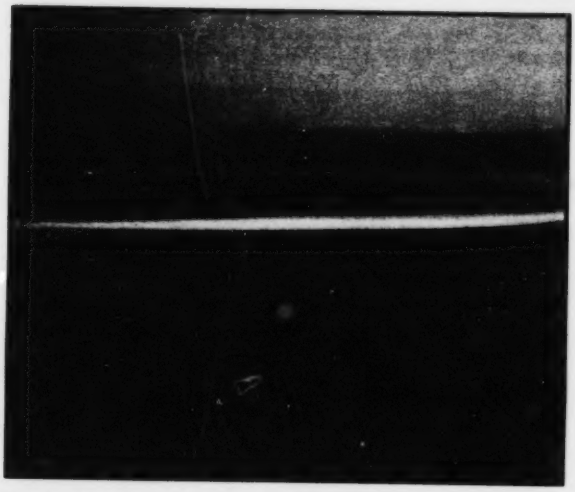
Salinization

Another major type of degradation is salinization. This is the increase in soluble salt content of a soil and results when water, carrying dissolved salts, evaporates at the soil surface, leaving the soluble salts at or near the soil surface. The most common salts in Alberta's soils are sulphates of sodium, calcium and magnesium, which form a white crust on the soil surface when the water evaporates. Traditionally, this white crust has been called "alkali" by farmers and is a common sight in the grassland regions of Alberta around sloughs, at the foot of slopes in seepage areas or depressions, and adjacent to irrigation canals.

All Alberta soils contain some water soluble salts,and as water moves through the soil these salts are carried along. The salts may move downward with percolating water, laterally when the water moves horizontally, or down-slope through porous subsurface soil strata, or upward when capillary rise or seepage from up-slope comes to the surface. Evaporation at the surface leaves these salts at the soil surface. Rainfall, or irrigation, moves them down again.

Most agricultural crops tolerate a low soluble salt content in soils, some more than others, but production is reduced, even to zero, if the salt content is too high. Some weeds are more salt tolerant than crops and give an indication of the presence of salts in the soil.

When soils are continuously cropped the plants ensure that, under Alberta's low rainfall, there is very little, if any excess water and therefore

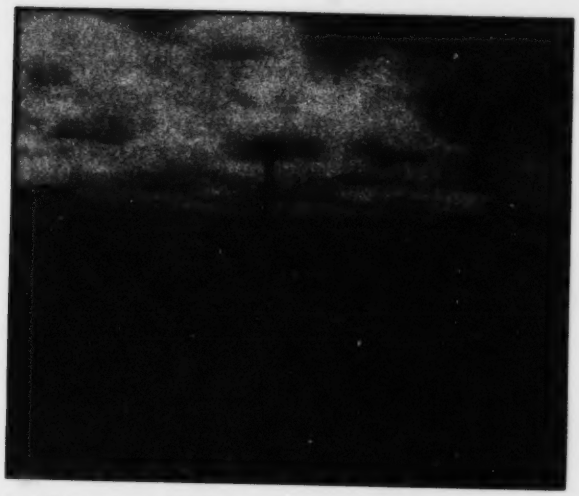


Salinization, indicated by white crust of soluble salts.

little seepage, and salts present in the soil remain where they are. When a field is summerfallowed however and weeds killed there may be a moisture surplus below the root zone in years of above normal rainfall, and seepage will occur. Salts can then be transported to lower parts of a field or a depression. Here an increase in salt content of the soil occurs to the point where crops can no longer grow.

Irrigation can lead to problems of seepage because of surplus water present. If no tile drainage is present to carry away the excess water and its dissolved salts the salts are transported to down-

slope or depression areas. In recent years, extensive irrigation system rehabilitation has been undertaken, including canal lining and reclamation of salinized areas. Drainage tiles have been installed with costs shared by district and producer. Irrigated acreage affected by salinity is now on the decrease as a result.



Installing subsurface tile drain to help in removal of soluble salts and excess water.

Under dryland farming these practices may help:

1. Minimizing summerfallowing which may often conserve excessive amounts of moisture and lead to lateral transport of salts to low lying areas,
2. Planting deep-rooting crops, such as alfalfa, to draw down the water table in recharge or around depressional areas,
3. Applying barnyard manure to salt-affected areas to increase the water holding capacity of the soils, and
4. Using salt-tolerant crops. For example, barley is more tolerant than oats, brome grass more tolerant than timothy, and alfalfa more tolerant than red clover.

Unfortunately there is no known way of neutralizing the effects of soluble salts in the soil on crop growth. This is serious because agricultural production is being reduced by salinization of soils. About 1.2 million hectares of dryland are affected by saline seepage, with an average crop yield reduction of 25%. Government researchers, both provincial and federal, are giving special attention to the problem under both dryland and irrigation farming conditions. Areas of saline soils have been mapped and reclamation methods are being studied, tested and demonstrated.

Agriculture Canada, Alberta Agriculture, and the PFRA all have extensive programs in operation to help farmers with problems of soil salinity. Offices of one or all of these agencies can be contacted in Edmonton, Lethbridge, Hanna or Vegreville.

Under the Soil Conservation Area Programs (SCAP) Agriculture Service Boards conduct cooperative field tests like this one.

Current Conservation Efforts in Alberta

During the late 1970s and the 1980s there has been a marked increase in attention paid to conservation of soil and water by governments and the general public. Special departments of government have been established to deal specifically with conservation problems. This section outlines the progress.

Research Efforts

Research in soil and water conservation has a long and impressive history at the Agriculture Canada Research Station at Lethbridge. Numerous publications report on the long-term research carried on there. Their minimum-till and zero-till plots are among the oldest in the world. At the Lethbridge Station and at the University of Alberta an increased attention has been given to soil organic matter, to salinity, and to water erosion studies. The map showing the water erosion potential of Alberta's soils, published by the Agriculture Canada Alberta Pedology Unit in 1985, has already been mentioned. The Alberta Agriculture Irrigation and Conservation Division published in the same year a map showing soil erosion potential of wind in Alberta. The same Division made a conservation tillage survey in 1988 to determine attitudes and practices of Alberta farmers. Also receiving continued attention by this government division are:

1) Climate and weather patterns,
2) Residue management by reduced tillage and chemical fallow,
3) Snow management by alternating stubble heights and barrier strips, and
4) Water harvesting by on-farm storage of snow melt and summer rains.

Other centres of research of federal and provincial agencies are at Lacombe, Vegreville, Brooks and Bow Island.

In 1984 and 1985 PFRA augmented its staffing in Alberta to assist in soil conservation efforts. Area conservationists were located in Lethbridge, Hanna, Vegreville and Peace River to provide technical, material and financial support to Alberta Agriculture Conservation Programs. In addition, the long-standing PFRA Rural Water Supply Development Program has elements that complement the Alberta Agriculture On-farm Water Management Program.

The Alberta Environment Department established a research laboratory at Vegreville in 1979 which includes in its program problems of soil and water management. A PFRA unit there also continues with its programs of land reclamation and water conservation.

A major step forward by the Alberta government was the establishment in 1978 of the "Farming for the Future Research Program". This was a commitment by the government to fund agricultural research in order to improve net farm income and the long-time viability of agriculture in Alberta. The program has funded to date over 500 research projects in all aspects of agriculture, but including many in irrigation and soil management. Research stations, universities, and private companies have been assisted by this important program.

In 1988 a further step forward was taken by the Alberta government when it established the "Alberta Agricultural Research Institute Matching Grants Program". In its first year the program has funded five projects in the area of soil conservation.

Alberta Agriculture has adopted this stated "Mission": to support the maintenance and further development of a viable agriculture and food economy in Alberta. The Department considers its "Business" to be: 1) Agricultural business unit development, 2) Infrastructure development and 3) Agriculture resource conservation. Its stated goals include, "To promote conservation of Alberta's soil and water resources". The research program outlined above indicate the dedicated effort to achieve these aims.

The organization of Alberta Agriculture over recent years also shows the concern for conservation in this province. For many years soil and water conservation was the responsibility of the Soils Branch in the Plant Industry Division. Since 1984 there has been a separate Conservation and Development Branch with two sections: 1) a soil conservation section, including soil and water engineering, and soil salinity and 2) a farm water management section, including engineers and weather specialists. Parallel units to these are based in Lethbridge.

A recent (1987) joint effort by federal and provincial governments was the establishment of the Canada/Alberta Agreement on Soil, Water, and Cropping Research and Technology Transfer. The object of this agreement, referred to as CARTT, was to support research and technology transfer projects in soil and water conservation and management.

At the time of writing this story of conservation in Alberta a major federal-provincial agreement is being formulated which will result in a large input of funds to support efforts in soil and water conservation.

Extension Work in Conservation

Along with the increased progress of research in recent years has been an expanded use of extension and demonstration programs.

Agricultural Service Boards have continued their encouragement of conservation practices with greater success as a result of new programs and greater assistance. They have helped in the establishment of grassed waterways, have demonstrated conservation tillage practices, and have encouraged improved crop management. These have all stimulated a greater awareness of the value of soil and water conservation. Salinity problems have been addressed by demonstrations of drainage and cropping techniques to counter the presence of soluble salts.

Alberta Agriculture's Conservation and Development Branch has drawn major attention to conservation by arranging farmer meetings on the subject, and especially by its Soil Conservation Area Programs. The Branch has also produced large posters on conservation, and films on the subject. Some films prepared have been: "Gone With The Wind Too", "Oh Gully", "A Matter of Soil" (a prize-winning film), and "Water, Water". A film on conservation tillage will soon be available. The Irrigation Division also produced some award winning films, including "Soil Salinity - The Indicators".

The Farming for the Future program, referred to earlier, in addition to its support of research, has

also sponsored an "On-farm Demonstration Program". The goal here was to display the use of new technology, such as chemical fallow, deep plowing, reclamation work, minimum and zero tillage in continuous cropping, and sub-soiling with amendments. Over 500 demonstrations have been arranged in the last decade.

Cooperation between the federal and provincial governments has sought to review policies counterproductive to soil conservation. A Task group studied means of increasing public awareness of soil conservation problems. National "Soil Conservation Weeks" have been organized to help achieve the latter goal. Water conservation will soon be included in this extension program.

Alberta Environment has produced several sets of student reference materials and activity sheets for use by teachers and students in Elementary and Junior High Schools on the topic "Water Supply in Alberta". These materials emphasize the importance of water in our environment and the need for its conservation.

In conjunction with the Education and Agriculture Departments PFRA is helping to develop soil conservation material to support school curricula. Material for kindergarten to Grade 3 has been prepared and work is currently in progress on material for Grades 7-9.

In the field of water conservation Aiberta Environment encourages: 1) development of a social consciousness toward the creation of individual obligations to use water without waste, 2) emphasis on greater water use efficiencies to reduce water losses and excessive use, 3) water conserving technology in irrigation, and 4) water reuse where such is feasible. The government is committed to a program to prevent or control water pollution. Pollution must be controlled at its source. In flood plain management Alberta Environment's goal is to minimize potential flood damage.

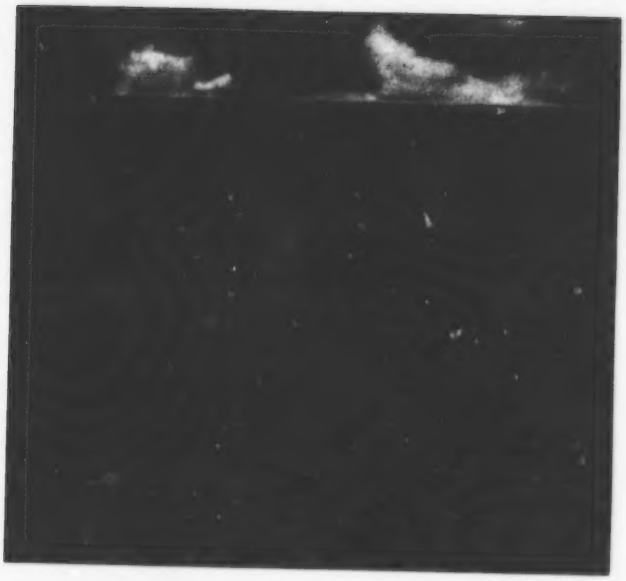
Public Awareness

Several groups in our society have reflected the growing public interest and concern about the conservation of our resources, including soil and water.

The Soil Conservation Society of America (now the Soil and Water Conservation Society) was established in the 1940s, and in 1981 a Chapter of this organization was formed in Alberta. The Alberta Chapter now has over one hundred members and is the agency, with CARTT's assistance, responsible for this publication. It is the Chapter sponsoring the 44th Annual meeting of the SWCS being held in Edmonton July 30-Aug.2,1989. Visitors and delegates from all over the continent are attending to see what we Albertans are doing to conserve our soil and water resources.

The Agricultural Institute of Canada published in 1987 a statement on "Land Use and Soil Degradation" in Canada. This 8-page leaflet reflects the concerns of Canadian Agrologists, including those in Alberta, regarding the fate of our limited areas of good agricultural soils. The Institute's publication in 1984 of "Will the Bounty End?" has been referred to earlier.

Among farmers themselves the many groups recently organized to deal with conservation problems have already been mentioned. Many other groups deal with some aspect of soil or water conservation. "Ducks Unlimited" is well known to all and its interests extend far beyond the borders of Alberta, as do also those of "The Canadian Water Resources Association". Other private organizations are devoting their attention to such topics as environmental concerns, or specific aspects of crop production such as organic farming. All attest to our society's concern at the present time about our environment, our food supply, and the conservation of our resources.



Extensive cooperative field tests will result in new and better ways to conserve soil and water.

The Future

What is ahead of us in conservation of soil and water? Four aspects are discussed here: new conservation practices, climate change, sustainable agriculture and conservation motivation.

New Conservation Practices

No doubt in the years ahead new techniques, new tillage and seeding machinery, new crops, new soil management programs, and new water conserving methods will appear on the scene. Drought-proofing is already a well-used term and carries with it the idea that a farmer must be prepared to cope with dry years when they come.

How can he do this? How can he conserve and make use of every drop of precipitation, whether rain or snow? How can snow-melt be kept from running away? How can evaporation from the soil be checked? How can water-use efficiency of crops be increased? These are problems in water conservation which researchers will help solve.

To counter wind and water erosion what are the best methods for the farmer to maintain plant-residue (trash) cover on the soil surface? What are the best ways to summerfallow (assuming this is justified in some years on some soils)? Are chemical fallowing and zero tillage options? A host of problems await research and solution. Many of these problems are under investigation now and some preliminary findings are being published.

The Annual Meeting of the Soil and Water Conservation Society and the Society's Journal are important avenues for bringing new techniques and research results to the attention of the public. The Information Services of Alberta and Canada Agriculture continue to publish bulletins and news releases on the latest research findings.

Climate Variability and Change

Is our climate changing? Is there going to be an enhanced greenhouse effect? Are the extreme weather events like tornadoes,heat waves, cold spells and droughts due to climate change or variability? Unfortunately we have good carefully gathered meteorological records for only a relatively short time when we want to know long-range trends. Computers are helping us to handle masses of data and climate models are helping us to reach some tentative conclusions. Weather forecasting beyond a day or two in Alberta is not yet very reliable.

While the percentage of carbon dioxide in the atmosphere may be increasing slowly, accepted as a fact by many researchers, the long-range effects are uncertain. Will the mean annual temperature rise a degree or two in the next few decades? If it does will the polar ice caps melt or will increasing carbon dioxide in the atmosphere cause more cloud formation, precipitation and more snowfall? There are simply no hard and fast research conclusions at this time, but they are being steadily gathered and we'll know more by the end of the century, hopefully.

Central Albertans followed with great interest and concern attempts to suppress hail by cloud seeding, starting in the 1950s. Conflicting data led to a government-sponsored research program of cloud seeding. After many years of cloud seeding, and evaluation of data collected, the results are still inconclusive. Cloud seeding for rainfall increase and snow augmentation on the other hand is a widely accepted concept in some parts of the world and may have some future in Alberta.

Satellite imagery of cloud cover, more precise and novel ways of monitoring our climate, and computer modelling will all help us in the years ahead to adapt to what the weatherman brings, and hopefully we shall know when to expect a flood or an extended drought, a wind storm or a heat wave, in time to be prepared.

Sustainable Agriculture

In 1987 the National Task Force on Environment and the Economy defined "sustainable economic development" as "development which ensures that the utilization of resources and the environment today does not damage prospects for their use by future generations". We can apply the definition to sustainable agriculture under the following terms:

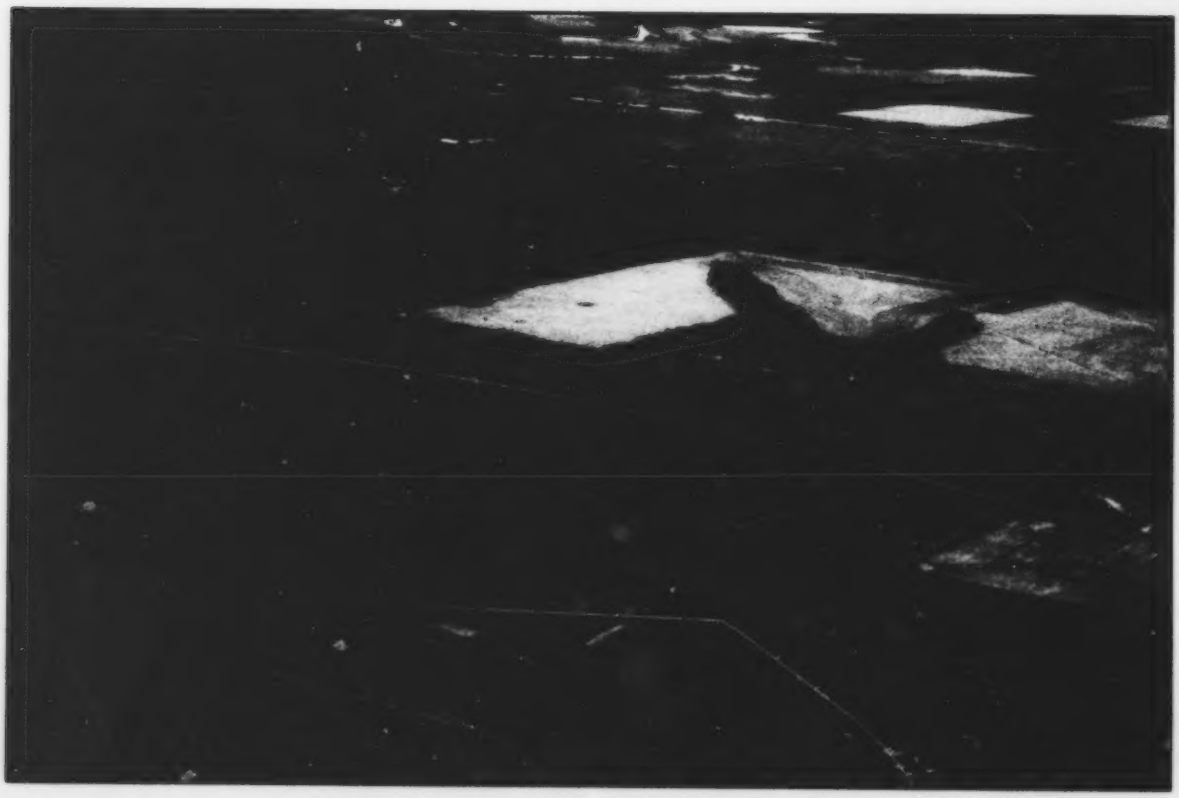
1) In crop management planning we must substitute for "cropping for maximum economic returns" the idea "cropping with the environmental impact in mind and the effect on future generations".
2) Non-renewable resources, such as rich virgin soils, must be used in the most economic way possible but using such practices as will ensure their continued productivity. Some of our poorer soils could be improved to higher fertility levels.
3) Land, water and atmosphere must not be damaged.
4) Intergenerational equity means protecting the interests of future generations by managing the environment safely today.

Conservation Motivation

From society's viewpoint conservation of soil and water are desirable goals and the landholder must farm accordingly. The farmer, faced with making a living and depending entirely on his own resources and immediate cash returns for his labor, has a different viewpoint.

Dr.O.S.Longman, former Deputy Minister of Agriculture, in 1960 wrote, "Land is a peculiar form of property. In its original state it is not a product of labor but a gift of nature to all mankind. We boast of the fact that we have a policy of private ownership of land. Nonetheless, the land belongs to the people. What is needed is more vigilant observance of the rights of each – private initiative and the public interest in land. The private occupier of land in reality holds a privilege granted by society, hence has an obligation to society equal to the opportunity the possession of the land represents. To enforce this obligation is the duty of government as the agent of society."

How can the government achieve this end? If society expects the farmer to spend time and trouble to save the soil for future generations, then society should lend a hand. This principle has already been put into effect in Alberta in the form of numerous assistance programs carried out by the Agricultural Service Boards and branches of Alberta Agriculture for individual farmers. What is needed is a broader policy affecting all who till the soil and use the water, to ensure that they are motivated to use soil and water conserving practices.



"O Canada, glorious and free . . .
We stand on guard for thee."

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